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VOLUME I
(Report)

FORMER WAREHOUSE AREA
SITE INVESTIGATION REPORT

BUCKLEY AIR NATIONAL GUARD BASE
AURORA, COLORADO

Prepared for:

Departments of the Army and the Air Force
National Guard Bureau
5109 Leesburg Pike
Falls Church, VA 22041-3201

Prepared by:
Stone & Webster Environmental Technology and Services
7677 East Berry Avenue
Denver, CO 80111-2137

Prepared under:
Contract No.: DAHA90-94-D-0009
Delivery Order No. 0009

December 22, 1997

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GC	gas chromatography
GC/MS	Gas Chromatograph/MassSpectrometry
gpd/ft	gallons per day per foot
GPR	ground penetrating radar
GQAPP	Generic Quality Assurance Project Plan
GSHP	Generic Safety and Health Plan
HCl	Hydrochloric Acid
HPLC	High Performance Liquid Chromatography
HSA	hollow stem auger
HSWA	Hazardous and Solid Waste Amendments
IDW	Investigation derived waste
IRP	Installation Restoration Program
IRPIMS	Installation Restoration Program Information Management System
LNAPLs	light non-aqueous phase liquids
MAP	Management Action Plan
MCLGs	Maximum Contaminant Level Goals
MCLs	maximum contaminant level
mg/L	milligrams per liter
MSL	mean sea level
MTBE	methyl tertiary butyl ether
MVSB	Motor Vehicle Storage Building
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NGB	National Guard Bureau
NPDES	National Pollutant Discharge Elimination System
O_2	oxygen
OMS	Organizational Maintenance Shop
OSHA	Occupational Safety and Health Act Administration
OU	operable unit
OVM	organic vapor monitor
PA	Preliminary Assessment
PAHs	polynuclear aromatic hydrocarbons
PCE	perchloroethylene/ tetrachloroethylene
PCBs	polychlorinated biphenyls
PID	Photoionization detector
POL	petroleum, oil, and lubricant
PP	Priority Pollutant
ppb	parts per billion
ppm	parts per million
PVC	polyvinyl chloride
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RI	remedial investigation
RI/FS	Remedial Investigation/FeasibilityStudy
RM	Remedial Measures
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act

SAIC	Science Applications International Corporation
SDG	Sample Delivery Group
SI	site investigation
SOW	Statement of Work
SSHSP	Site-specific Safety and Health Plan
SSQAPP	Site Specific Quality Assurance Project Plan
SVOCs	semi-volatile organic compounds
SWEC	Stone & Webster Engineering Corporation
SWL	static water level
TCE	trichloroethylene
TIC	tentatively identified compounds
TCLP	Toxicity Characteristic Leaching Procedure
TOC	top of casing
TPH	total petroleum hydrocarbons
TSCA	Toxic Substance Control Act
TSD	treatment, storage, and disposal (facilities)
ug/l	micrograms per liter
USAEHA	U. S. Army Environmental Hygiene Agency
USCWTP	Upper Sand Creek Water Treatment Plant
USGS	United States Geological Survey
USTs	Underground Storage Tanks
VOCs	volatile organic compounds
VPHs	volatile petroleum hydrocarbons

APPENDICES

Appendix Note:

Appendix H, which contains the laboratory data packages and Data Evaluation Report is maintained at the Buckley Air National Guard Base Repository for the Former Warehouse Area Site Investigation. This information is available for public review. For further information contact:

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To schedule an appointment to review Appendix H contact Buckley Air National Guard Base at the above.

LIST OF ACRONYMS

AF	Air Force
AGE	aerospace ground equipment
ANG	Air National Guard
ANGB	Air National Guard Base
ANGRC	Air National Guard Readiness Center
AOC	Area of Concern
ARARs	applicable or relevant and appropriate requirement
ASTM	American Society of Testing Materials
AWQC	ambient water quality criteria
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylenes
CAA	Clean Air Act
CDPHE	Colorado Department of Public Health and Environment
CE	civil engineering
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act.
cm/sec	centimeters per second
CO_2	carbon dioxide
COC	chain-of-custody
CO MCL	Colorado Primary Drinking Water Regulations Maximum Contaminant Level
COPC	Constituents of potential concern
CSMS	Combined Support Maintenance Shop
CWA	Clean Water Act
DD	Decision Document
DERA	Defense Environmental Restoration Account
DNAPLs	dense non-aqueous phase liquids
DOD	Department of Defense
DOT	Department of Transportation
DRMO	Defense Reutilization Marketing Office
EA	Environmental Assessment
EC	Environmental Coordinator
ECAS	Environmental Compliance Assessment System
EM	electromagnetic
EPA	U. S. Environmental Protection Agency
EPHs	extractable petroleum hydrocarbons
F°	Degree Fahrenheit
FFA	Federal Facility Agreements
FFS	Focused Feasibility Study
FID	flame ionization detector
FOL	Field Operations Leader
ft	feet
ft/sec	feet per second
ft/yr	feet per year
FW	Fighter wing
FWA	Former Warehouse Area
GAC	granular activated carbon

EXECUTIVE SUMMARY

Stone & Webster Environmental Technology & Services conducted a Site Investigation under the Installation Restoration Program of the Former Warehouse Area at the Buckley Air National Guard Base (the Base) in Aurora, Colorado. The purpose of the investigation was to determine if constituents of concern found in groundwater at the City of Aurora's Upper Sand Creek Water Treatment Plant, just north of the Former Warehouse Area, were also present at the Former Warehouse Area; if so, it would be determined whether or not further action would be necessary under the IRP. Field investigation activities complied with the procedures established in the Final Former Warehouse Area Site Investigation Work Plan, dated October 4, 1996, prepared by Stone & Webster for the Departments of the Army and the Air Force National Guard Bureau (Contract DAHA90-94-D-0009, Delivery Order No. 0009).

Buckley Air National Guard Base, located approximately 4.5 miles east of Denver, is approximately 3,328 acres in size. The U.S. Army Air Corps operated the Base from 1942 to 1946 when the Base was deactivated, its ownership transferred to the State of Colorado, and it was occupied by the Colorado Air National Guard. In 1947 the U.S. Navy assumed control of a portion of the Base for use as a training area. In 1959 the U.S. Navy deactivated the station and transferred the property back to the Colorado Air National Guard. The Base has since stored and used various types of materials during its history in support of its primary missions of combat training, transient aircraft support, and search and rescue response.

The Site Investigation focused on the Former Air Force Motor Pool and Former Depot areas of the Former Warehouse Area. The investigation consisted of a geophysical survey followed by drilling, sampling, and analysis of soil gas, soil, and groundwater samples. The Site Investigation was initiated following the discovery of volatile organic compounds, herbicides, and pesticides in groundwater at the City of Aurora's Upper Sand Creek Water Treatment Plant located approximately 100 feet directly north of the Former Warehouse Area. The Site Investigation confirmed that chemical constituents present in groundwater at the City of Aurora's Upper Sand Creek Water Treatment Plant are present upgradient at the Former Warehouse Area. As a result, a more detailed investigation of the Former Warehouse Area is recommended.

The surficial geology and hydrogeology of the Former Warehouse Area was examined. Eolian (i.e., windblown) deposits, consisting of contiguous thick sequences of unconsolidated brown clays and silts with traces of very fine sand with non-contiguous lenses of alluvial clayey sand, sandy clay, and sandy silts lie directly atop the erosional surface of the Denver Formation. Shallow groundwater at the Former Warehouse Area primarily occurs within lenses of alluvial material within a matrix of hydraulically tight eolian silts and clays. Shallow groundwater flows to the north and north east at an average rate of approximately 2.4 feet/year.

Results of a geophysical study, utilizing magnetic and electromagnetic sensing equipment, identified numerous magnetic anomalies within the Former Air Force Motor Pool associated with

demolition debris and abandoned underground utilities. The geophysical study did not indicate the presence of a reported dry well, buried vertical well casing/pipe, or any pipe that may have been used as a drain within the Former Depot area.

Background surface soil and groundwater samples were collected and analyzed. At two of the four background locations, organic compounds were found and these locations were eliminated as background locations for the Former Warehouse Area. One background groundwater sample location contained tetrachloroethylene a concentration of 6.2 µg/l slightly greater than the Colorado Primary Drinking Water Regulation Maximum Contaminant Level of 5 µg/l. All background groundwater samples contained total and dissolved selenium concentrations that exceed the Colorado Maximum Contaminant Level for drinking water.

Two empty underground storage tanks and associated piping, the fuel pump island foundation, and a concrete pad are the only visible structures remaining at the Former Air Force Motor Pool area. Demolition debris and underground utilities are present in the general area. Suspected source areas within the Former Air Force Motor Pool area include the two underground storage tanks and associated piping and fuel pump island, the west side of the concrete pad, the southwest corner of the investigated area at soil boring FWASB07, and the center of the investigated area in the vicinity of soil boring FWASB05.

Low concentrations of volatile organic compounds were discovered in the soil gas collected from the Former Air Force Motor Pool area. Acetone and tetrachloroethylene were the most prevalent of these compounds. Soil gas results were used to select the placement of soil borings.

Volatile and semi-volatile compounds reported within surface soils of the Former Air Force Motor Pool included acetone, xylenes, methylene chloride, toluene, benzo(g,h,i)perylene, benzo(k)fluoranthene and bis(2-ethylhexyl)phthalate, chrysene, diethylphthalate, fluoranthene, indeno(1,2,3-CD)pyrene, phenanthrene, pyrene, volatile petroleum hydrocarbons, and extractable petroleum hydrocarbons. Subsurface soil volatile and semi-volatile compounds found include acetone, methylene chloride, ethylbenzene, xylenes, 2-butanone, 2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenz(a,h)anthracene, pyrene, chrysene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and di-n-butylphthalate. Volatile petroleum hydrocarbons and acetone occurred in the highest concentrations.

Surface soil metals present at the Former Air Force Motor Pool area include arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, silver, thallium, and zinc. The maximum concentrations of all present surface soil metals were greater than the maximum concentrations of background surface soil metals. Subsurface metals found included arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, thallium, and zinc. The maximum concentrations of arsenic, beryllium, chromium, copper, nickel, selenium, and thallium that were reported are greater than the maximum concentrations found in surface soil. All surface and

subsurface metal concentrations are within the concentration ranges for those metals reported in the Western United States.

Groundwater immediately downgradient of the Former Air Force Motor Pool area is impacted by low levels of volatile and semi-volatile compounds including 1,1-dichloroethene, 1,2-dichloroethene, carbon tetrachloride, tetrachloroethylene, butylbenzylphthalate, and di-n-butylphthalate. Copper, lead, selenium, and zinc were reported in groundwater. Carbon tetrachloride and selenium were found in groundwater above the Colorado Primary Drinking Water Regulation Maximum Contaminant Level.

Warehouses 515 and 516 are the only structures remaining within the investigation area of the Former Depot. Warehouses 505, 506, and 507/OMS 9 have been demolished. Suspected contaminant source areas include an area directly adjacent to the west, south, and east side of Former Warehouse 505; the area between Former Warehouse 507/OMS 9 and Warehouse 516; and the area north of Former Warehouse 505 in the vicinity of soil boring FWASB14 where a four-inch pipe protrudes from the ground.

The soil gas survey conducted at the Former Depot area focused on the area in the vicinity of Warehouses 505, 506, and 507. Acetone and tetrachloroethylene are the most prevalent volatile organic compounds reported. The highest concentration of soil gas volatile organic compounds occur on the east and southeast side of former Warehouse 505. Soil gas results were used to select placement of soil borings.

Organic compounds reported in Former Depot area surface soils included acetone, toluene, tetrachloroethylene, 2-butanone, acenaphthelene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate chrysene, dibenz(a,h)anthracene, di-n-butylphthalate, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, extractable petroleum hydrocarbons, and the polychlorinated biphenyl compound aroclor-1260. The highest concentration of organic compounds in surface soils occurs in soil areas not recently disturbed by demolition activities between warehouses 506, 507, 515, and 516 and in the paved area north of former Warehouse 506 and 507. Volatile and semivolatile organic compounds reported in subsurface soil include acetone, methylene chloride, toluene, 2-butanone, tetrachloroethylene, trichloroethylene, butylbenzylphthalate, and di-n-butylphthalate. The distribution of tetrachloroethylene increased and was found in the deepest soil sampling interval at six locations. Polychlorinated biphenyls were not found in subsurface soils. Pesticides and herbicides were not found in surface or subsurface soils at the Former Depot area.

Metals reported in Former Depot area soils include arsenic, beryllium, cadmium, chromium, copper, lead, nickel, silver, thallium, and zinc. The maximum concentration of all discovered Former Depot area surface soil metals are greater than or equal to the maximum concentration of local background surface soil metals. Metals reported in subsurface soil samples include arsenic, beryllium, cadmium, chromium, copper, lead, nickel, silver, thallium, and zinc. Concentrations of most subsurface soil metals are slightly greater than surface soil concentrations. All surface

and subsurface soil metal concentrations are within the concentration ranges for those metals reported in the Western United States.

The concentrations of tetrachloroethylene, trichloroethylene, chromium and selenium were discovered above the Colorado Primary Drinking Water Regulation Maximum Contaminant Level in groundwater downgradient of the Former Depot area.

Based on the Site Investigation results, it is recommended that a Remedial Investigation be conducted at the Former Warehouse Area. Additional environmental investigation work at the Former Warehouse Area includes:

- determining if chemical constituents are impacting background areas from unknown upgradient sources,
- conducting additional surface and subsurface soil sampling in the vicinity of the Former Air Force Motor Pool and Former Depot areas to locate and determine the extent of source areas; and,
- conducting long-term monitoring of groundwater levels and contaminant concentrations to investigate the rate of contaminant movement and the effects of precipitation/infiltration and evapotranspiration on groundwater levels.

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1.0 INTRODUCTION

This Site Investigation (SI) Report presents the results of the Former Warehouse Area (FWA) Site Investigation at the Buckley Air National Guard Base (Buckley ANGB or Base) located in Aurora, Colorado. Work was conducted under the Installation Restoration Program (IRP). Stone and Webster Environmental Technology & Services (Stone & Webster) conducted this investigation and prepared this report for the Departments of the Army and the Air Force National Guard Bureau under Contract DAHA90-94-D-0009, Delivery Order No. 0009.

The SI field investigation activities and analytical results are presented in this report. Field investigation activities followed the procedures established in the Final Former Warehouse Area Site Investigation Work Plan, dated October 4, 1996, prepared by Stone & Webster for the Departments of the Army and the Air Force National Guard Bureau. Specifically, this SI Report provides background information on the FWA, describes the environmental setting and field investigation activities, presents investigation results, identifies areas of concern (AOCs), and provides conclusions and recommendations.

1.1 BACKGROUND

The Buckley ANGB is located in the City of Aurora, Arapahoe County, Colorado and is approximately 4.5 miles east of Denver in the north central portion of the state. The Base is bordered by 6th Avenue on the north, Highway 30 on the east, and by Buckley Road and the Jewell Avenue extension on the west (Figure 1-1). The Buckley ANGB is an active air base that has existed since the early 1940's and is approximately 3,328 acres in size.

Constituents of potential concern (COPC) have been reported in groundwater by the City of Aurora at it's Upper Sand Creek Wastewater Treatment Plant (USCWTP) located at the northeast corner of East 6th Avenue and Tower Road (18551 East 6th Avenue). Reported COPC include volatile organic compounds (VOCs), herbicides, and pesticides.

The USCWTP is on the northern boundary of the Buckley ANGB across East 6th Avenue. The southern boundary of the USCWTP is approximately 100 feet (ft) directly north of the Buckley ANGB across 6th Avenue. The City of Aurora's report, dated January 22, 1993, states that the source of the COPC in groundwater detected at the USCWTP is suspected to reside within the Buckley ANGB property boundary in the vicinity of the FWA. The SI examined the FWA's contribution to groundwater COPC at the USCWTP site and potential COPC soil source areas within the FWA.

1.2 PROJECT PURPOSE AND SCOPE

The purpose of the SI was to confirm the presence and determine the nature of soil and groundwater COPC at the FWA. The FWA SI was accomplished by conducting a sequential environmental field investigation involving a geophysical survey, followed by a drilling and

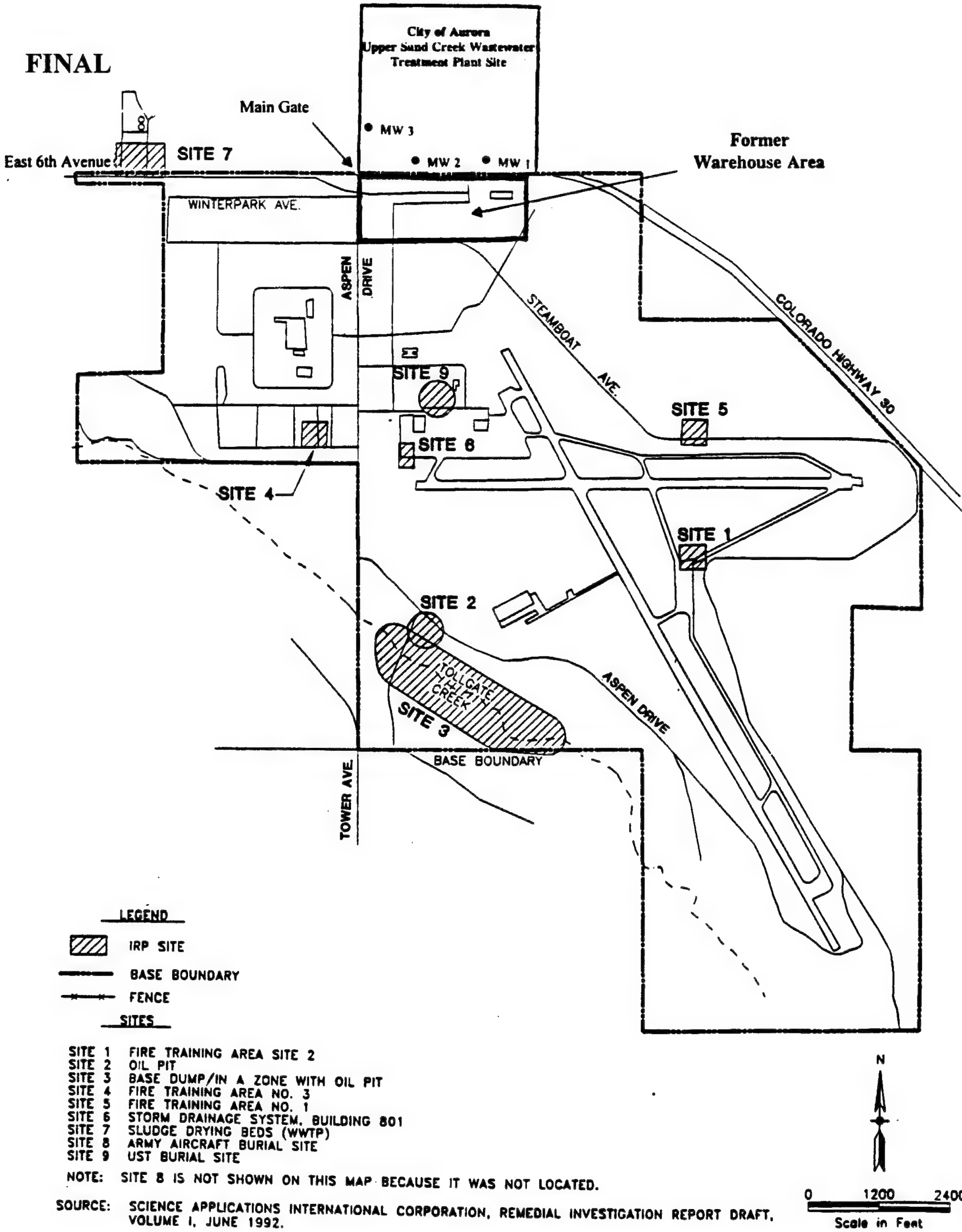


Figure 1-1
General Layout of the Buckley ANGB Indicating Locations of the Former Warehouse Area, USCWTP, and Previously Investigated IRP Sites.

sampling program that included collecting and analyzing soil gas, soil, and groundwater samples within the FWA.

This FWA SI report defines the nature of COPC present at the FWA, identifies potential source areas for COPC, and characterizes site geology and hydrogeology. All site investigation activities were conducted in accordance with the Final Former Warehouse Area Site Investigation Work Plan, dated October 4, 1996, prepared by Stone & Webster for the Departments of the Army and the Air Force National Guard Bureau. The methods and procedures presented in the Work Plan followed U.S. EPA guidance documents and Air National Guard (ANG) requirements.

Detailed background information based on previous investigations conducted at the Buckley ANGB are not presented in this report. Instead, summary information is presented and documents containing the detailed site information are referenced.

1.3 FORMER WAREHOUSE AREA INVESTIGATION METHODOLOGY

The FWA SI approach required identification of source areas, followed by the determination of the nature of COPC within soils and groundwater. This was accomplished by conducting a geophysical survey and by performing soil gas, soil, and groundwater sampling and analysis. The SI focused on the Former Depot and Former Air Force (AF) Motor Pool areas of the FWA.

Geophysical survey techniques were utilized to locate potential underground storage tanks (USTs), dry wells, and other unidentified underground source areas in the vicinity of the Former AF Motor Pool area. Two USTs reportedly installed in the motor pool area were identified. The dry well reportedly located in the vicinity of Warehouse 505 was not found. The exact location of these COPC sources could not be determined based on the preliminary review of base records conducted when preparing the FWA SI Work Plan.

A soil gas survey was performed to identify areas of potential soil and groundwater COPC. The survey was initiated at potential sources identified by the preliminary review of the Buckley ANGB records that was conducted as part of the SI Work Plan development. The soil gas survey identified areas of VOCs beneath the land surface.

Soil borings were completed within areas suspected of containing VOCs based on the soil gas survey results. Soil borings allowed the collection of soil samples to identify site lithology and to perform laboratory analysis to characterize the type and amount of VOCs.

Piezometers and monitoring wells were installed and sampled, primarily to determine shallow groundwater flow direction and gradient within the FWA vicinity. This information was used to locate monitoring wells upgradient and downgradient of source areas. Installing piezometers and monitoring wells allowed the collection of aquifer material for physical identification and the piezometers were used to determine groundwater flow directions and hydraulic characteristics. Aquifer hydraulic characteristics were determined by performing aquifer slug tests on piezometers and monitoring wells. Monitoring well and piezometer samples were used to determine the types and concentration of COPC within groundwater.

1.4 SITE INVESTIGATION REPORT STRUCTURE

This SI Report is structured in the following fashion.

- Section 1.0 provides an introduction to the FWA SI and presents the purpose, scope, and investigation methodology.
- Section 2.0 furnishes facility background information, including a summary of previous investigations.
- Section 3.0 presents the regional and local environmental setting of the Buckley ANGB and FWA.
- Section 4.0 provides a detailed description of the FWA, discusses industrial practices conducted at the facility, and identifies AOCs investigated.
- Section 5.0 describes in detail the types of investigation procedures and protocols used to conduct the SI and provides a discussion of the strategy and sample location rationale.
- Section 6.0 presents the FWI SI results, including geological and hydrogeological information; geophysical survey results; and analytical results from soil gas, soil, and groundwater samples.
- Section 7.0 presents a summary and conclusions of the FWA SI.
- Section 8.0 provides recommendations for additional investigation activities to further define the impact of the FWA on the local environment.
- Section 9.0 lists cited references.
- Appendices A though G and I through K present supporting technical information.
- Appendix H is entitled "Location of Repository for Analytical Data and Quality Assurance/Quality Control Evaluation Results." This appendix contains all laboratory data packages and the data evaluation report. This information is not included in this report but maintained at Buckley ANGB for review. This appendix also lists the names, addresses, and phone numbers of the Buckley ANGB Environmental Manager and ANG Project Manager to be contacted to view the appendix.

2.0 FACILITY BACKGROUND INFORMATION AND DESCRIPTION

This section provides a description of the Buckley ANGB and a summary of previous significant environmental investigations conducted at the Base. Information is summarized from previous investigations (Enpro, 1993 and Science Applications International Corporation [SAIC], 1995), historical surveys (Powers Elevation Corporation, 1995), and the IRP Management Action Plan (Radian Corporation, 1995).

2.1 FACILITY DESCRIPTION AND BASE HISTORY

The 140th Fighter Wing (FW) of the Colorado Air National Guard is stationed at the Buckley ANGB. The base is located in the City of Aurora, Arapahoe County, Colorado approximately 4.5 miles east of Denver in the north central portion of the state. The Base is bordered by 6th Avenue on the north, Highway 30 on the east, and by Buckley Road and the Jewell Avenue extension on the west (Figure 1-1). The Buckley ANGB is an active air base that has existed since the early 1940's and is approximately 3,328 acres in size.

The Federal Government purchased 5,740 acres of land outside Denver, Colorado in 1942 and 1943 and designated it as Buckley Field. U.S. Army Air Corps B-17 and B-24 bombardiers and armorers were trained at Buckley Field. Basic and arctic training was also conducted. In 1946, the U.S. Army deactivated Buckley Field and transferred its ownership to the State of Colorado. Buckley Field was then occupied by the Colorado ANG for training purposes. In 1947, the U.S. Navy assumed control of a portion of Buckley Field for use as a training area and renamed it Naval Air Station - Denver, Colorado. The Colorado ANG retained control of the remainder of the field. In 1959, the U.S. Navy deactivated the station and transferred the property to the Colorado ANG. The station became a part of Buckley ANG Base. The 140th FW has since been activated for the Korean Conflict in 1951, the Berlin Crisis of 1961, and the Pueblo Crisis of 1968; the 140th FW was also the first ANG fighter squadron deployed to Vietnam.

The Colorado ANG has stored and used various types of materials during its history in support of its primary missions of combat training, transient aircraft support, and search and rescue response. Table 2-1 is a summary of the operations conducted at the Base and the activities associated with these operations.

2.2 PREVIOUS INVESTIGATIONS

In January of 1993, the City of Aurora, Colorado completed a Phase I and Phase II Environmental Assessment (EA) of the USCWTP site on the northeast corner of East 6th Avenue and Tower Road (18551 East 6th Avenue), Aurora, Colorado. This property, which the City of Aurora is attempting to develop, is located less than 100 ft north of the Buckley ANGB's northern boundary, east of the Main Gate (see Figure 1-1).

Table 2-1
Summary of Base Operations and Associated Substances Activities

Period	Type of Operation	Mission/Weapon System	Activity
1942 - 1946	U.S. Army Air Corps	B-17, B-24 bombardier and armor training, basic training, and arctic training	Aircraft, vehicle, and aerospace ground equipment (AGE) maintenance; petroleum, oil, and lubricant (POL) storage; engine, machine, electric, paint, and battery shop activities
1947 - 1959	Naval Air Station - Denver, Colorado	Training and transient aircraft support	Aircraft, vehicle, and AGE maintenance; POL storage; engine, machine, electric paint, and battery shop activities
1959-1991	140th Fighter Wing	A-7D, T-43, AH-1F, UH-1H, OH-6A, C-26, and T-42 transient aircraft support	Aircraft, vehicle, and AGE maintenance; POL storage; engine, machine, electric, paint, and battery shop activities
1991-present	140th Fighter Wing	F-16, T-43, UH-1H, and OH-6A transient aircraft support; C-26 helicopter mission	Aircraft, vehicle, and AGE maintenance; POL storage; engine, machine, electric, paint, and battery shop activities; hydrazine storage

The Phase I and II USCWTP EA Report indicated VOCs were reported in groundwater. These VOCs included tetrachloroethene (PCE), trichloroethene (TCE), xylenes, toluene, ethylbenzene, and 2-butanone. Groundwater flow direction determined by the study indicated that the Buckley ANGB may be an upgradient source for the observed groundwater VOCs.

In September 1995, the Colorado Department of Public Health and Environment reviewed the City of Aurora EA report and requested that Buckley ANGB expedite and implement an additional site characterization of the base property in the vicinity of the USCWTP. This area of the Buckley ANGB is known as the FWA.

2.2.1 IRP Investigations

The IRP investigations have consisted of a Preliminary Assessment (PA), SI, and Remedial Investigation (RI). Descriptions and findings of each study is presented. Detailed information on these investigations is summarized in the Colorado ANG Buckley ANGB, RI Report (SAIC, 1995).

2.2.1.1 Preliminary Assessment

The PA, consisting of a Phase I Records Search, was completed for the Buckley ANGB in September 1982. The PA identified eight IRP sites and recommended sites 1 through 6 for further investigation, based on their Hazard Assessment Rating Methodology (HARM) scores. No further investigation was recommended for IRP Sites 7 and 8 because their HARM scores reflected low potential for contaminant migration. The location of IRP Site 8 was never determined by the PA.

2.2.1.2 Site Investigation

An SI was completed in March 1986 for IRP Sites 1 through 6 identified by the PA. A second SI was completed for IRP Sites 7 and 8 in May 1987. These sites were initially studied to confirm or deny the existence of suspected environmental contaminants at each site. The SI Report recommended IRP Sites 1 through 7 for additional investigation. IRP Site 8 was recommended for no further response action.

2.2.1.3 Remedial Investigation

An RI was performed at IRP Sites 1 through 7 to define the extent of confirmed environmental COPC at each of the six sites. The RI was initiated in October 1988 and an RI Report completed in August 1995. The results and conclusions of the RI are presented in a RI Report of the Buckley ANGB (SAIC, 1995). The RI Report recommended long term monitoring for Sites 2 and 3, and a non-time-critical source removal action for Site 4. A remedial action was recommended for Site 4. Sites 1, 5, 6, and 7 were recommended for no further response action.

The Base's IRP site were numbered differently in the RI Report. Table 2-2 summarizes site numbering for the IRP and RI Report.

Table 2-2
IRP Site Numbering

Site	Installation Restoration Program	Remedial Investigation Report
Fire Training Area No. 2	1	3
Base Dump/In a zone with Oil Pit	2 & 3	1
Fire Training Area No. 3	4	4
Fire Training Area No. 1	5	2
Storm Drainage System Building 801	6	5
Sludge drying Beds	7	6
Army Aircraft Burial Site	8	7
UST Burial Site	9	no number assigned

Final No Further Response Action Decision Documents (NFRA DDs) for sites 5 and 7 were completed in July 1992, and Final NFRAP DDs for Sites 1 and 6 were completed in November 1992.

Site 9 (UST Burial Site) was identified in 1985, remediated by January 1987, and closed under the Colorado UST program.

Figure 1-1 shows the locations of the nine IRP Sites at the Buckley ANGB relative to the FWA. Table 2-3 summarizes the COPC reported at IRP sites and the recommendations presented in the RI report.

A summary of findings for each IRP Site is briefly summarized in the following paragraphs.

<u>Site 1 - Former Fire Training Area #2</u>

Petroleum hydrocarbon (mainly benzene, toluene, and xylene) were detected in soil samples collected from Site 3. No site-related groundwater COPC was found in the monitoring wells installed at Site 3. A baseline public health evaluation indicated no significant carcinogenic or noncarcinogenic risk associated with the limited soil COPC at the site. No immediate action was recommended for this site. A groundwater monitoring well was suggested to provide data for a decision document to support the elimination of the site from further IRP study. Site 1 is located approximately 7,500 ft southeast of the FWA.

<u>Sites 2 and 3 - Base Dump/In A Zone With Oil Pit</u>

The RI identified two limited areas of low concentrations of petroleum hydrocarbons and the herbicide 2,4-DB in soil at Site 1. Volatile petroleum hydrocarbons (VPH) were found and consisted primarily of benzene, toluene, ethylbenzene, and xylene (BTEX compounds). The concentrations found were close to background levels and were not believed to be linked to any disposal activity in the landfill vicinity.

TCE and low levels of 1-2-dichloroethene and bis(2-ethylhexyl)phthalate were reported in groundwater samples collected from monitoring wells at Site 1. A baseline public health risk assessment indicated no significant carcinogenic or noncarcinogenic risk associated with the presence of the limited soil and groundwater COPC at the site. A long term monitoring program was recommended to determine the potential for COPC migration. Sites 2 and 3 are located approximately 7,500 ft south of the FWA.

<u>Site 4 - Fire Training Area #3</u>

The RI discovered petroleum contamination (primarily benzene, toluene, and xylene) and limited levels of the chlorinated organic solvents TCE and PCE in the soil at the site. COPC were not found in the groundwater at the site above the applicable or relevant and appropriate requirements (ARARs) for the site. A baseline public health risk assessment indicated no significant carcinogenic or noncarcinogenic risk associated with the soil COPC at the site. A

Table 2-3
Summary of RI Results and Recommendations
Buckley ANG Base

Site Designation	COPC Detected in Soil	COPC Detected in Groundwater	Results/Recommendation
Site 1 - Former Fire Training Area #2	Benzene, toluene, xylene	None	Installation and sampling of a groundwater monitoring well is recommended to provide data for a decision document to support the eliminating the site from further IRP study.
Sites 2 and 3 - Base Dump/In Zone With Oil Pit	BTEX compounds	Trichloroethene, 1,2-dichloroethene, bis(2-ethylhexyl)phthalate	A baseline public health risk assessment indicated that there is no significant carcinogenic or noncarcinogenic risk associated with the presence of the limited soil and groundwater COPC at the site. A long-term monitoring program was recommended to determine the potential for COPC migration.
Site 4 - Former Fire Training Area #3	Benzene, toluene, xylene, TCE, PCE	None	Non-time critical source removal action for soil within the burn pit area is recommended.
Site 5 - Former Fire Training Area #1	None	None	Further study by direct push sampling is recommended to confirm absence of COPC to eliminate site from further IRP study.
Site 6 - Drainage Ditch	Petroleum, hydrocarbons, lead	Not sampled	A baseline public health evaluation indicated that there is no significant carcinogenic or noncarcinogenic risk associated with the limited soil COPC at the site. No immediate action is recommended. A groundwater monitoring well was suggested to provide data for a decision document to support eliminating the site from further IRP study.
Site 7 - Former Sewage Treatment Plant	Priority pollutant metals	None	A baseline public health evaluation indicated no significant risk associated with the metal COPC in soil at the site. No further action was recommended for the site. It was also recommended that a decision document be produced to eliminate the site from further IRP study.
Site 8 - Army Aircraft Burial Site			Site 8 was never located. No further action was recommended for the site. It was also recommended that a decision document be produced to eliminate the site from further IRP study.
Site 9 - UST Burial Site	Petroleum, hydrocarbons, lead		Site remediated by January 1987 and closed under the Colorado UST program.

non-time-critical source removal action for the soil within the burn pit area was recommended for Site 4. Site 4 is located approximately 5,000 ft southeast of the FWA.

Site 5 -Former Fire Training Area #1

No soil or groundwater COPC were reported at this location by the RI. The RI recommended further study of the site by a direct push soil sampling technique to confirm the absence of COPC and eliminate the site from further IRP study. Site 5 is located approximately 6,000 ft southeast of the FWA.

Site 6 - Storm Drainage System Building 801

Elevated levels of petroleum hydrocarbons and associated lead COPC were detected in one sediment sample collected from this site. A baseline public health evaluation showed no significant risk associated with the contaminated soil. No further immediate action was recommended for this site. A Final Decision Document was completed for this site in June 1992. Site 6 is located approximately 3,500 ft south of the FWA.

Site 7 - Sludge Drying Beds

Groundwater COPC were not detected at this site. Levels of priority pollutant metals were reported above background levels in soils within the sludge drying beds at the site. A baseline public health evaluation indicated no significant risk associated with the metal soil COPC in the sludge drying beds. No further action and a decision document to eliminate the site from further IRP study were recommended for the site. Site 7 is located approximately 4,500 ft east of the FWA.

Site 8 - Army Aircraft Burial Site

Site 8 has never been located and has been recommended for no further response action.

Site 9 - UST Burial Site

Site 9 contained four 12,500-gallon USTs and associated piping containing waste oil. The site was closed under the Colorado underground storage tank program. Site 9 is located approximately 3,000 ft south of the FWA.

2.2.2 Phase I/II Environmental Assessment of the USCWTP

In January 1993, a Phase I and Phase II EA was performed by Enpro Consulting Group of Denver, Colorado on the USCWTP site north of the FWA (Enpro, 1993).

The Phase I investigation indicated farming was the only significant land use for the property. Records reviewed from the EPA, Colorado Department of Health, Colorado Office of Oil Inspection, and Tri-County Health Department indicated there were no environmental permits,

no known pollution sources, and no direct evidence of spills or COPC at the property. Farming activities are currently continuing at this property.

Enpro's Phase II investigation consisted of surficial soil and groundwater sampling and analysis. Three monitoring wells (i.e., MW-1, MW-2, and MW-3) were installed as part of the investigation. Figure 1-1 and Figure 3-5 of Section 3 indicate the approximate location of these wells at the USCWTP site. Sample analysis indicated that residual concentrations of the herbicides 2,4-D, 2,4-DB, 2,4,5-T, 2,4,5-TP (silvex), and Dinoseb were present in the shallow soils. Elevated concentrations of chlorinated solvents and 2,4-D were detected in groundwater samples collected from the site. In addition, low levels of petroleum compounds were observed in all three wells. The COPC found included PCE, methylene chloride, acetone, carbon disulfide, 2-butanone, TCE, toluene, ethylbenzene, and xylenes. Table 2-4 summarizes the groundwater COPC reported by the Phase I/II EA of the USCWTP site and compares values to the primary drinking water regulations maximum contaminant levels (MCL).

Table 2-4
Summary of Phase I/II EA of the USCWTP Groundwater Results

Analyte (units)	MW-1	MW-2	MW-3	MCL
VOCs (µg/L)				
PCE	410			5
Methylene Chloride		2		
Acetone		13		
Carbon disulfide		1		
2-Butanone	41	11		
TCE	2			5
Toluene	4	1	1	1000
Ethylbenzene	6	1	1	700
Total Xylenes	31	5	3	10,000
Substituted Benzene*	144	19	7	
TRPH	0.5			
Herbicides (µg/L)				
2,4,-D			719	70
Dinoseb			14.5	7
Pesticides (µg/L)				
Aldrin			0.03	
Heptachlor Epoxide	0.07	0.12	0.12	0.2
Metals (mg/L)				
Silver		0.05		
Arsenic			0.024	0.05
Barium	0.44	0.34	4.9	2.0
Cadmium				0.005
Chromium				0.1
Lead	.009	0.0093	0.062	0.015 ~
Selenium				0.05
Mercury			0.0005	0.002
Copper	0.02	0.045	0.27	1.3 ~
Iron	31	42	310	
Manganese	0.87	0.51	38	
Zinc	0.11	0.12	0.74	
Nutrients (mg/L)				
Nitrates	8.6	10.3	4.85	
Sulfate	5690	3780	3520	400
Phosphorous		0.33	20	
Anions/Cations				
TDS (mg/L)	5590	5840	2860	
Specific Conductance (µMHOs/cm)	>5000	>5000	2470	

Note: The Phase I/II EA report does not indicate that groundwater metals samples were filtered.
* Tentatively identified substituted benzene compound.
~ The level for this contaminant represents an action level rather than a MCL. Treatment technique regulations are triggered when this action level is exceeded in a number of samples measured.

3.0 ENVIRONMENTAL SETTING

The following sections summarize regional and Base-wide environmental conditions, including a detailed discussion on local geology and hydrogeology.

This environmental setting of Buckley ANGB is summarized from the Buckley IRP RI Report (Science Applications International Corporation, 1995). An extensive study of the hydrogeological system along the Front Range of Colorado was recently completed by the United States Geological Survey (USGS). Principal groundwater aquifers, water quality, hydraulic characteristics, and geological structures were studied (Robson and Romero 1981a; Robson and Romero 1981b; Robson et al., 1981a; Robson et al., 1981b; Robson 1983; and Hillier et al., 1993). The following discussions are based on these studies and other references as cited.

3.1 METEOROLOGY

The climate of the Buckley ANGB area is characteristic of high plains and is classified as dry continental. The area experiences relatively low humidity, light precipitation, and abundant sunshine because it is situated a great distance from any moisture source and is separated from the Pacific Ocean by several mountain barriers. The weather at Buckley ANGB is influenced by four major air sources. These air masses include Arctic air from Canada and Alaska; warm, dry air from Mexico and the southwestern deserts; warm, moist air from the Gulf of Mexico; and moist, Pacific air modified (i.e. dried) by its passage over the mountains as it moves from west to east.

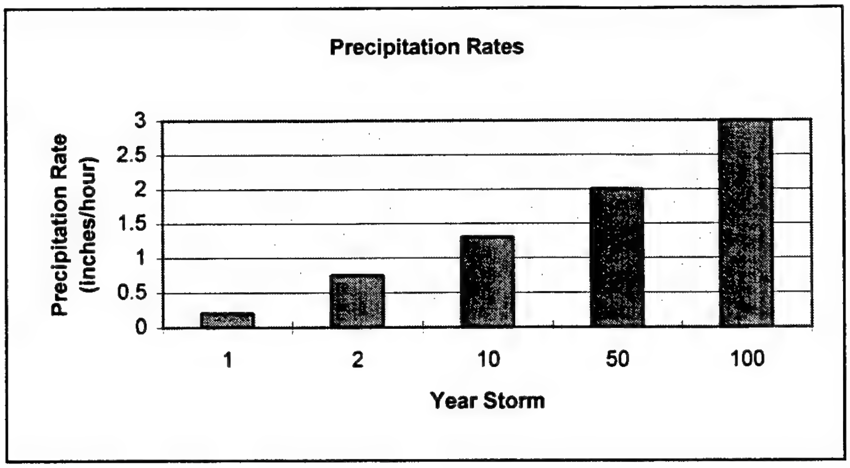
The temperatures in the area are relatively mild considering the latitude and high elevation. Extremely warm or cold weather is usually of short duration. Weather statistics for the Buckley ANGB are based on measurements obtained at the Cherry Creek Dam, approximately 5 miles southwest of the Base (National Oceanic and Atmospheric Administration (NOAA), 1982 and NOAA, 1992). The average annual temperature is approximately 49.7 degrees Fahrenheit (°F) with the average monthly temperature ranging from 30.0 °F during January to 72.1 °F during July.

Precipitation in the area is relatively sparse with the average annual rainfall equal to 16.65 inches. More than 75 percent of the precipitation falls between March and September, and monthly average precipitation ranges from 0.47 inches in January to 2.68 inches in May. The average annual snowfall is 51.8 inches. The average annual evaporation rate is approximately 50 to 60 inches per year. The area experiences an annual negative net precipitation because evaporation is greater than precipitation. The amount of annual negative net precipitation is unknown (Colorado Climate Center, 1996).

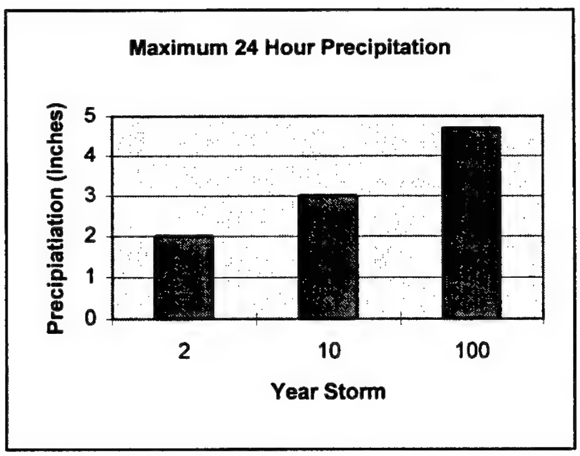
Several measures of rainfall intensity are provided below (Colorado Climate Center, 1996).

- Rainfall at the rate of 6 inches per hour has been recorded over a 10-minute period. However, on a yearly basis that rate is usually not exceeded for more than 1 minute.

- Using a duration of one hour, the following rate can be expected:



- Using a duration of 24-hours, the following rate can be expected:



The most rainfall ever recorded in the Denver metropolitan area at an official gauging station over a 24-hour period was 6.25 inches; that rainfall event occurred in the 1870's.

Prevailing winds are from the south at an average annual speed of 9 miles per hour (mph). The highest average monthly wind speed is 10 mph, which occurs in April.

3.2 GEOLOGY

Buckley ANGB is located within the Denver Basin of Colorado. The basin is filled with sedimentary rocks resulting from erosional processes within the mountains to the west. The basin is composed of seven geologic formations; in descending order they are: the Castle Rock Conglomerate; the Dawson Arkose; the Denver, Arapahoe, and Laramie Formations; the Fox Hill

Sandstone; and the Pierre Shale. Two generalized cross-sections of the Buckley ANGB hydrogeology are presented in Figure 3-1. Figure 3-2 is a generalized stratigraphic column for the Buckley ANGB. The Castle Rock Conglomerate and Dawson Arkose only occur within the central portion of the Denver Basin, therefore they are not present in the Buckley ANGB area, which is located in the outer portion of the Basin. The Denver Formation outcrops within the study area and is the only formation believed to be affected by hazardous waste handling, storage, and disposal activities at the Base. Surficial geology at the Buckley ANGB is presented in Figure 3-3.

The Denver Formation ranges in thickness from 600 to 1000 ft and is approximately 850 ft thick within the vicinity of the Buckley ANGB. The formation consists of a sequence of variable consolidated interbedded shale, claystone, siltstone, and sandstone which occurs in poorly defined lenticular beds.

Seventy percent of the formation is comprised of thick sequences of shale and claystone and 30 percent is comprised of coarser grained sediments irregularly dispersed in beds ranging in thickness from a few inches to as much as 50 ft. The formation is characterized by its olive, green-gray, brown, and tan color derived from erosional source in the mountains of like-colored basaltic and andesitic lava flows. Thin layers of coal and a high percentage of shales and mudstones also characterize this formation.

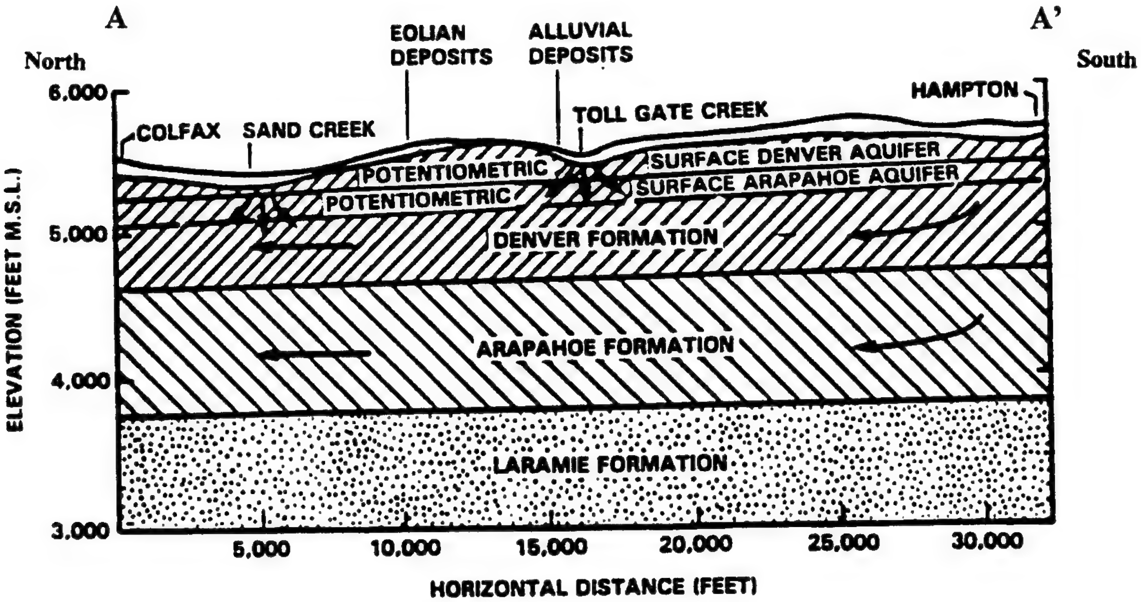
Bedrock consists of the Denver Formation which underlies the entire Buckley ANGB. Bedrock exists at a depth ranging from approximately 10 to 15 ft deep directly north of FWA at the Aurora USCWTP site. The Phase I and II EA report for this site indicates that bedrock consists of claystone, clayey sandstone, and sandy claystone which is typical of the Denver Formation. The bedrock is overlain by unconsolidated soils at this location.

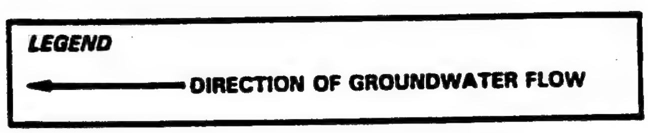
The Pleistocene and younger aged eolian soil deposits consist of unconsolidated fine sand and loess (silt) deposits ranging from 5 to 20 ft thick (United States Department of Agriculture [USDA], 1971). These deposits are primarily found in topographically high areas relative to the stream valleys. The eolian deposits are located primarily within the central portion of the Base including the FWA.

Eolian soils are present in the vicinity of the Aurora USCWTP site consist of eolian deposits of clay, silt, and occasionally silty sand that range in thickness from 10 to 15 ft.

3.3 SOILS

The Denver Formation is overlain by unconsolidated alluvial and eolian deposits at the Buckley ANGB. The alluvial deposits are confined to stream valleys which generally run southeast to northwest along the southwestern and northeastern sides of the Base. The alluvial deposits have a maximum thickness of 10 to 15 ft thick in the central portions of the valley and decrease in thickness along the valley flanks. These deposits have the general characteristics of the Denver Formation except that the material is unconsolidated and tends to be coarser and more homogeneous.





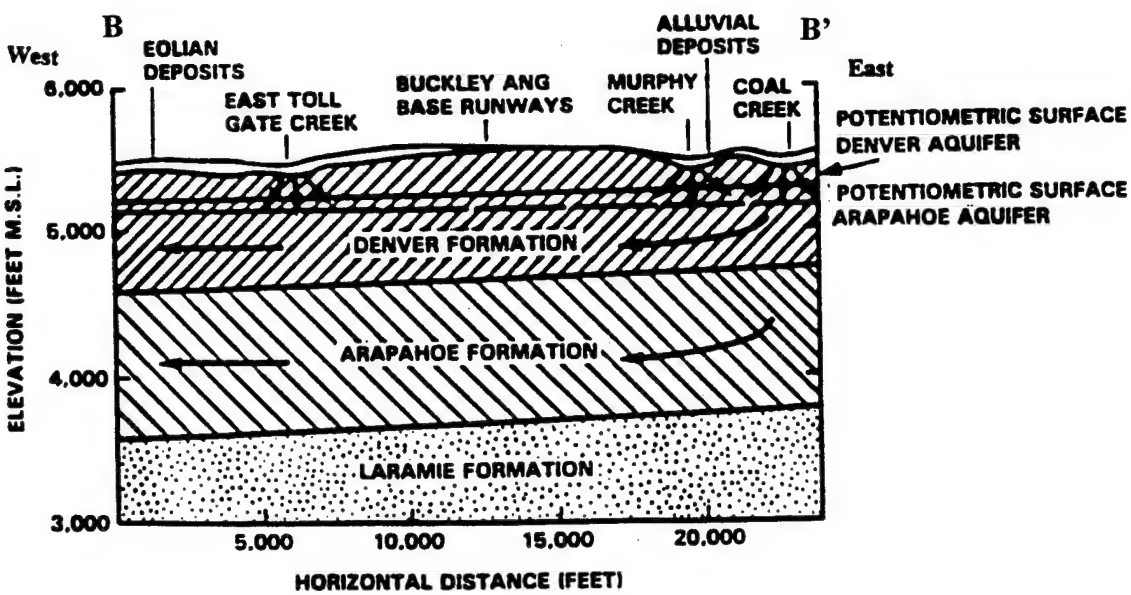


Figure 3-1
Generalized Hydrogeologic Cross-section of Buckley ANGB.
See Figure 3-3 for Cross-section locations (SAIC, 1995).

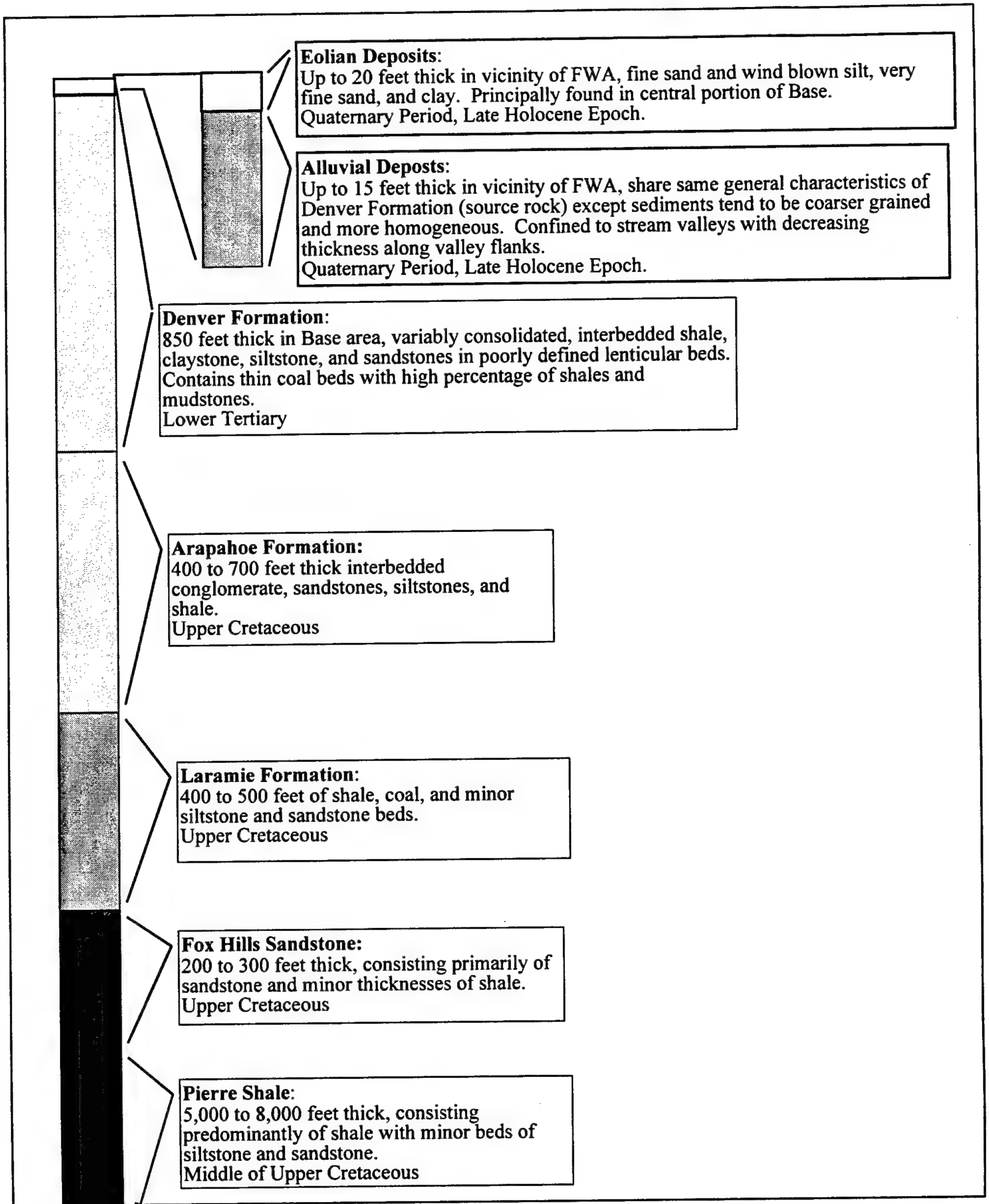


Figure 3-2
Generalized Stratigraphic Column for the Buckley ANGB (SAIC, 1995)

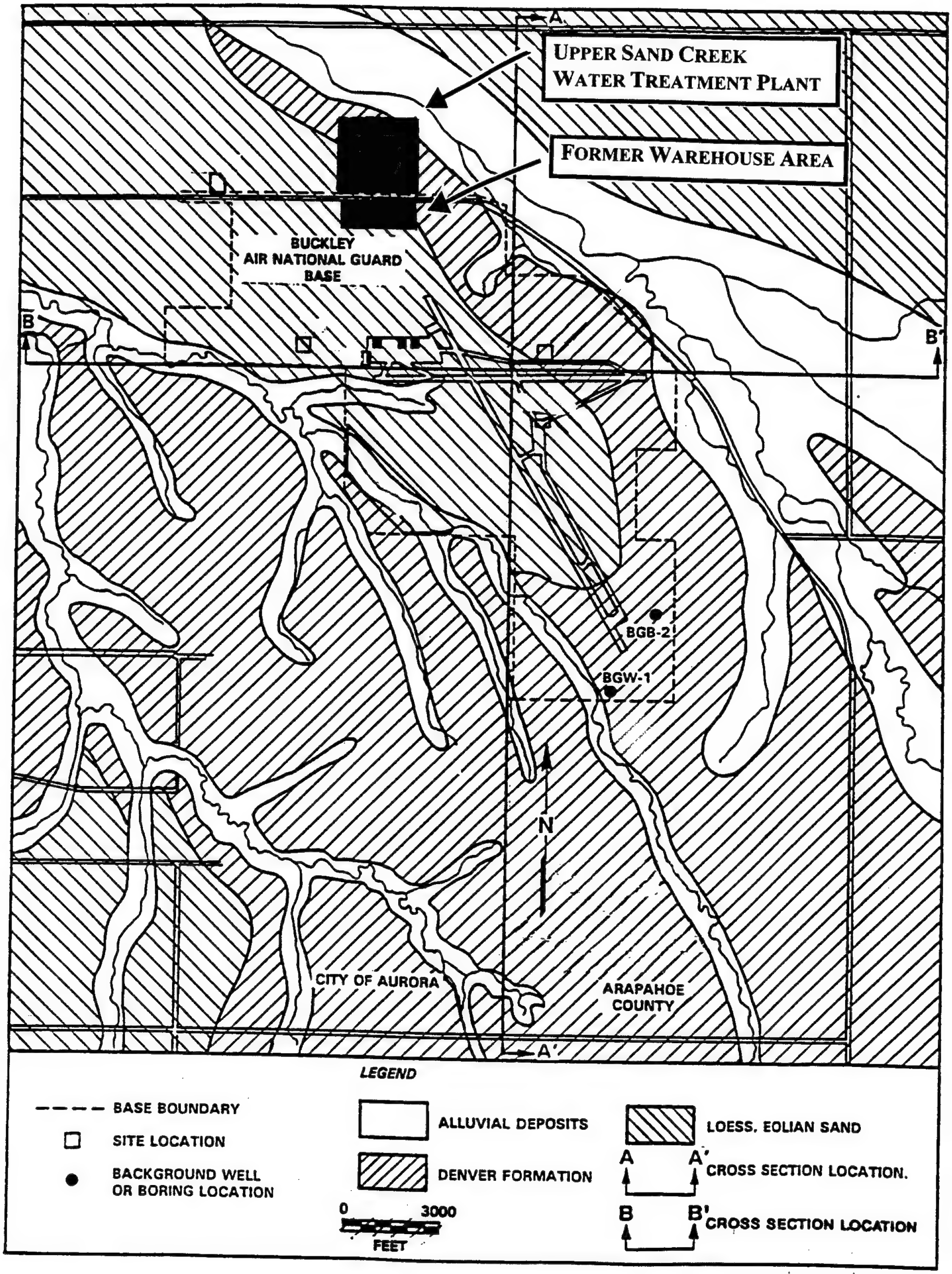


Figure 3-3
Surficial Geology at Buckley ANGB
(SAIC, 1995)

A soil survey map of Arapahoe County, including the investigation area, published by the USDA-Natural Resource Conservation Service (formerly the Soil Conservation Service) was reviewed. The soil in the FWA and immediately to the north is generally composed of "Fondis silt-loam," with slopes ranging from 1 to 3 percent. South of the FWA is a Fondis silt-loam of 3 - 5 percent slopes (USDA, 1971).

The Fondis silt-loam is described as having a surface soil about 6 to 7 inches thick, abruptly underlain by a dense "high-swelling" montmorillinitic clay subsoil about 18 to 20 inches thick. Depth to lime (caliche) is 14 to 20 inches in areas of 1 to 3 percent slope and less than 14 inches in the 3 to 5 percent slope areas, with soil pH in the range of 6.4 to 9.0. Reportedly, these soils are "plastic" when wet, with moderate to low permeability and a high available water-holding capacity (USDA, 1971).

The area immediately northeast of the investigation area is composed of the Renohill-Buick loam (3 to 9 percent slope) and Renohill-Litle-ThedalundComplex (9 to 30 percent slope). Both of these soils are shallow soils having loam or clay-loam topsoil 3 to 4 inches thick, underlain by calcareous clay or clay-loam subsoil with shale beginning at 24 inches or less (USDA, 1971).

Figure 3-4 displays the soils types present within a 4 mile radius of the FWA.

3.4 SURFACE WATER HYDROLOGY

There are two primary surface water drainage areas within the vicinity of the Buckley ANGB. East Toll Gate Creek flows toward the northwest along the Base's south and eastern boundary. Upper Sand Creek is closer to the FWA and flows to the northwest near the Base's north and western boundaries. At its closest point, Upper Sand Creek is approximately 1,500 ft from the eastern side of the FWA. Both creeks have very low flows and primarily drain agricultural and residential areas.

Surface water drainage within the FWA's immediate vicinity is controlled by land surface topography. Detailed drawings of the historical surface topography during FWA operation are not available. Previous and current building and demolitions within the FWA have disrupted local drainage patterns. Therefore, determining surface water flow patterns at the FWA are based on historical topographic maps and the most recent USGS topographic map of the Fitzsimons Quadrangle (see Figure 3-5).

In general, land surface topography slopes to the north and west at the FWA. Two drainage swales immediately to the east and west of the FWA drain to the north toward Upper Sand Creek. Surface drainage from the FWA probably flowed within drainage ditches along the railroad tracks and Base roads, and along the southern side of 6th Avenue toward each of the drainage swales. Historical topography of the FWA prior to construction of buildings and roads is presented in Figure 3-6. Historical surface topography is similar to current topography; however, ditch drainage patterns may have been different.

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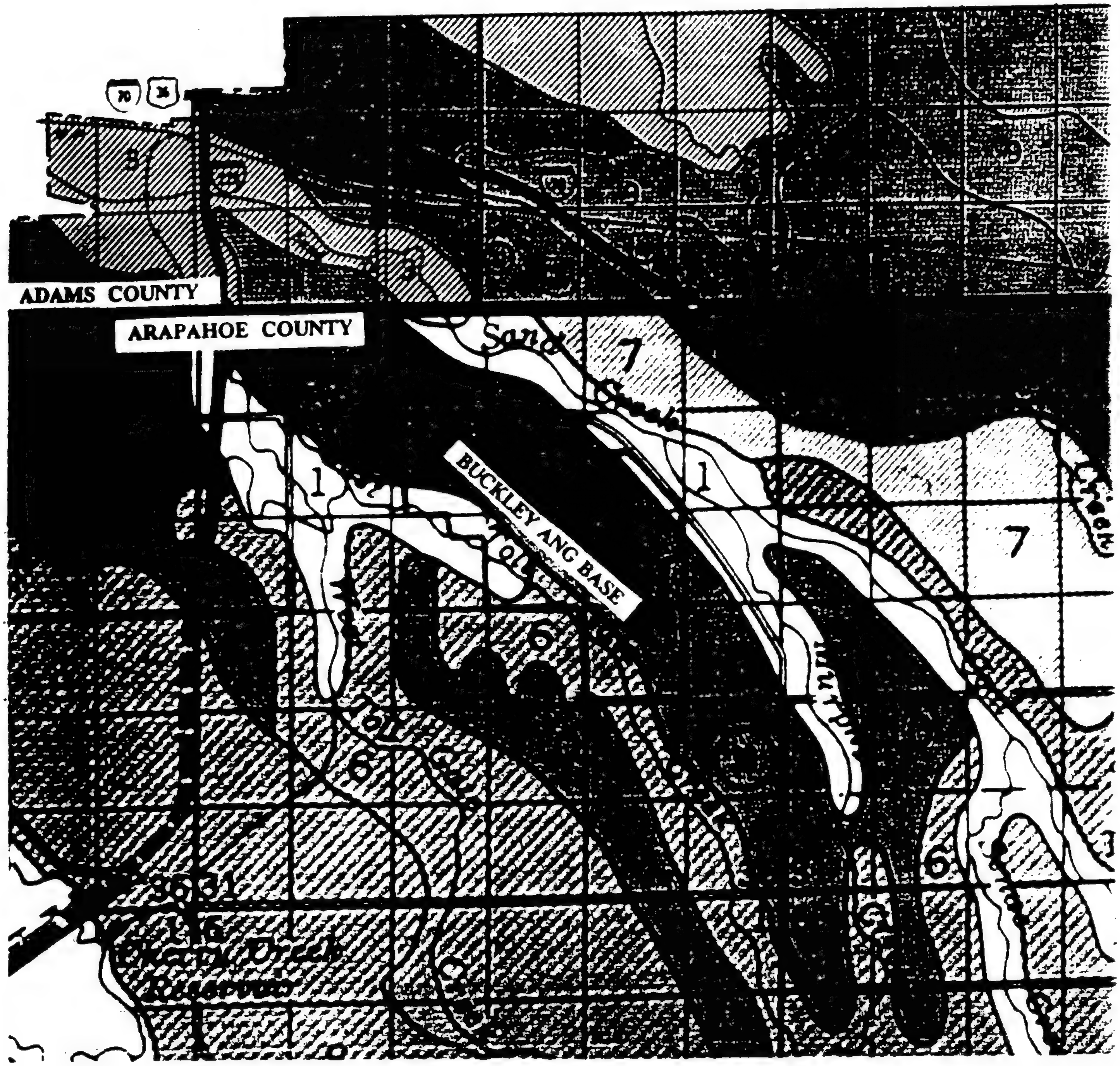

Soil Association	Arapahoe County	Adams County	Comments
Alluvial land-Nunn Asso.	1		Nearly level loamy/sandy soils, floodplains and terraces
Weld-Adena-Colby Asso.	3	1	Level to sloping, loamy, wind-deposited, uplands between creeks
Renohill-Buick-Litle Asso.	6		Sloping to steep upland loamy soils, loamy to clayey subsoil
Nunn-Bresser-Ascalon Asso.	7		Nearly level to undulating deep loamy soils, uplands and terraces
Truckton-Bresser Asso.	8		Deep, rolling, loamy and sandy soils w/ loamy subsoil, uplands
Fondis-Weld Association	10		Deep nearly level and gently sloping loamy soils w/clayey subsoil
Ascalon-Vona-Truckton Asso.		3	Nearly level to strong sloping, well to excessively drained, loamy/sandy, uplands
Nunn-Satana Association		4	Nearly level well-drained, loamy alluvial soils underlain by gravels
		5	Nearly level, poorly to well-drained, loamy and sandy, flood plains
Blakeland-Valent-Terry Asso.		7	Undulating to hilly, excessively drained, sandy soils, upland
Platner-Ulm-Renohill		9	Nearly level to strongly sloping, well-drained loamy alluvial soils, upland

SOIL ASSOCIATIONS OF THE BUCKLEY AI

Scale: 1:105,(
(Each Square = 1

Source

nents
ɔodplains and terraces
·osited, uplands between creeks
s, loamy to clayey subsoil
ɜmy soils, uplands and terraces
·ils w/ loamy subsoil, uplands
ng loamy soils w/clayey subsoil
ll to excessively drained, loamy/sandy,

ılluvial soils underlain by gravels
:d, loamy and sandy, flood plains
ained, sandy soils, upland
/ell-drained loamy alluvial soils, upland

SOIL ASSOCIATIONS OF THE BUCKLEY AIR NATIONAL GUARD BASE AREA

Scale: 1:105,600
(Each Square = 1 sq. mi.)

Source. Natural Resources Conservation Service
(Formerly Soils Conservation Service)

Soil Survey, Arapahoe County, 1971
Soil Survey, Adams County, 1974

COLORADO
AIR NATIONAL GUARD
AURORA, COLORADO

FIGURE 3-4

SOIL ASSOCIATIONS OF THE BUCKLEY ANGB AREA

STONE & WEBSTER ENVIRONMENTAL TECHNOLOGY & SERVICES

Drawn By	Approved By	Drawing No
BJA 11/4/97	PS	05219017O-4-4

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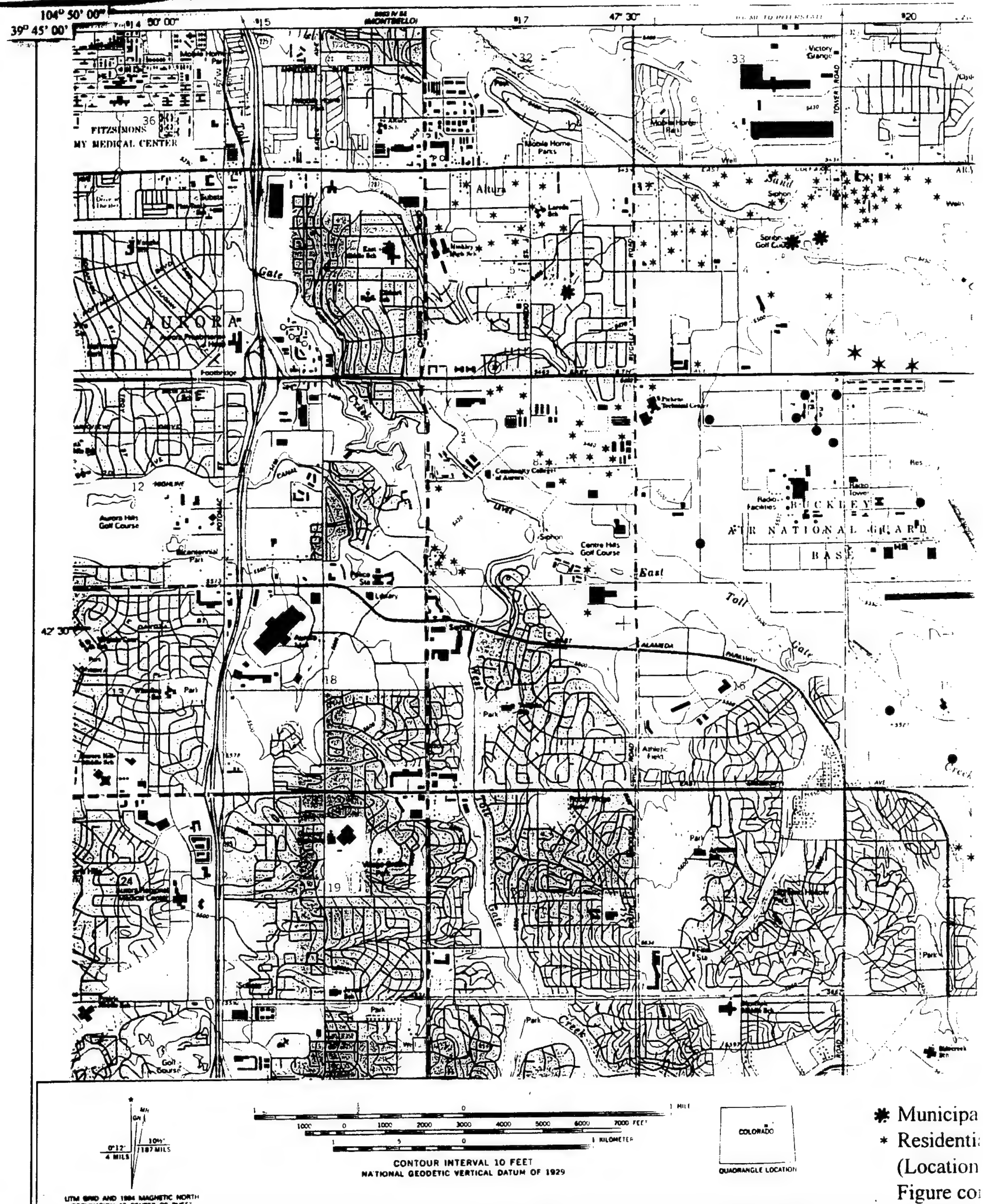
104° 50' 00"
39° 45' 00'
47' 30"
42' 30"
FITZSIMONS
MY MEDICAL CENTER
AURORA
Aurora Hills Golf Course
Centennial Park
Centre Hills Golf Course
Community College of Aurora
BUCKLEY
AIR NATIONAL GUARD
BASE
Radio Tower
Victory Grange
Mobile Home Park
Sand Creek
East Toll Gate
ALAMEDA PARKWAY
Athletic Field
Golf Course
Park
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
UTM GRID AND 1984 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
COLORADO
QUADRANGLE LOCATION
1 MILE
7000 FEET
1 KILOMETER
* Municipa
* Residenti
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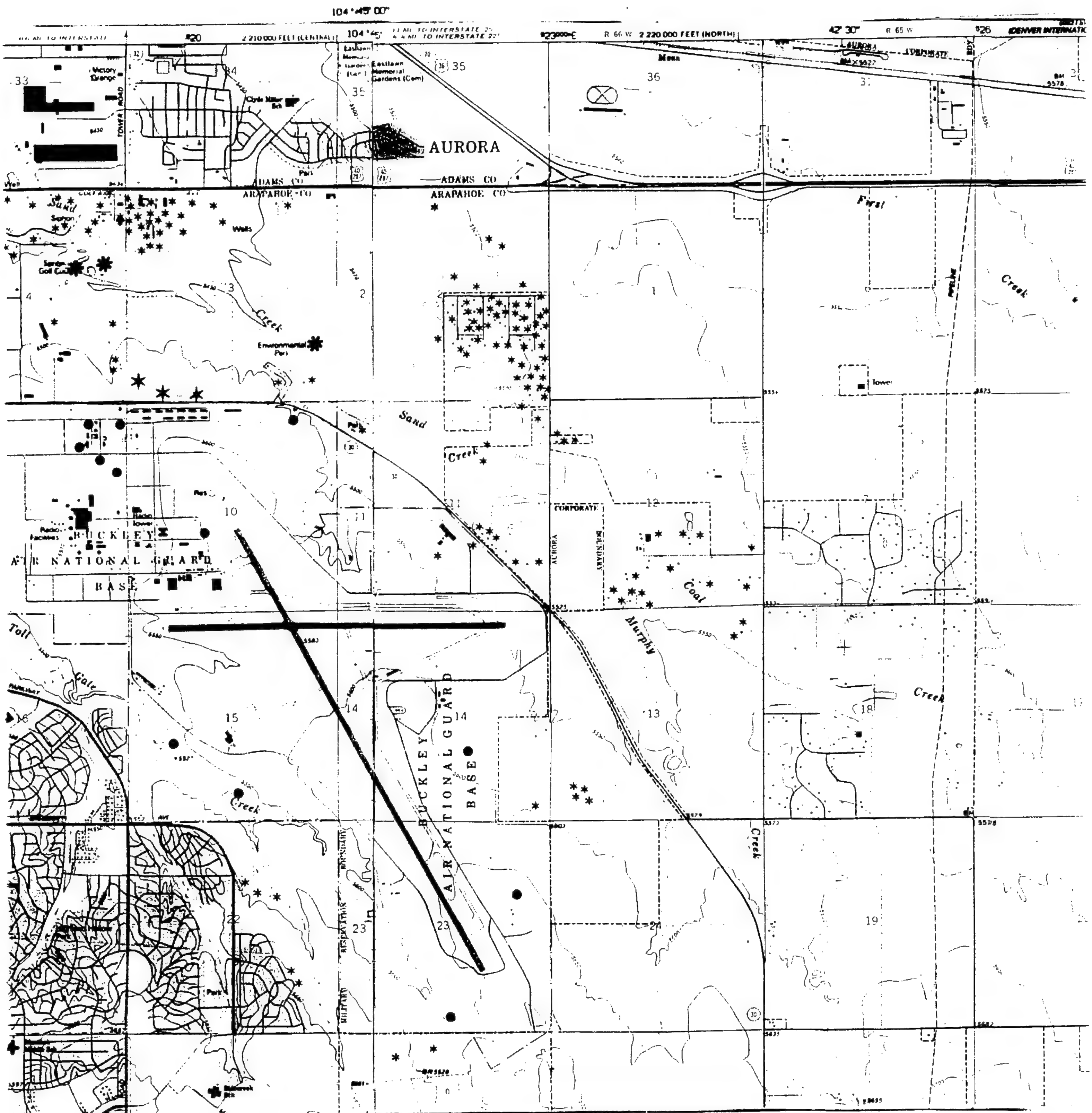

✱ Municipal Well
* Residential or Agricultural Well
(Location of wells are approximate)
Figure comprised of USGS Fitzsimons and Coal Creek quadrangles

✶ USCWTP Monitoring Well
● Buckley ANGB Well

Fi
Topographic Ma
Surrounding Are
Municipal, Resid
Water Wells Wit

(2)

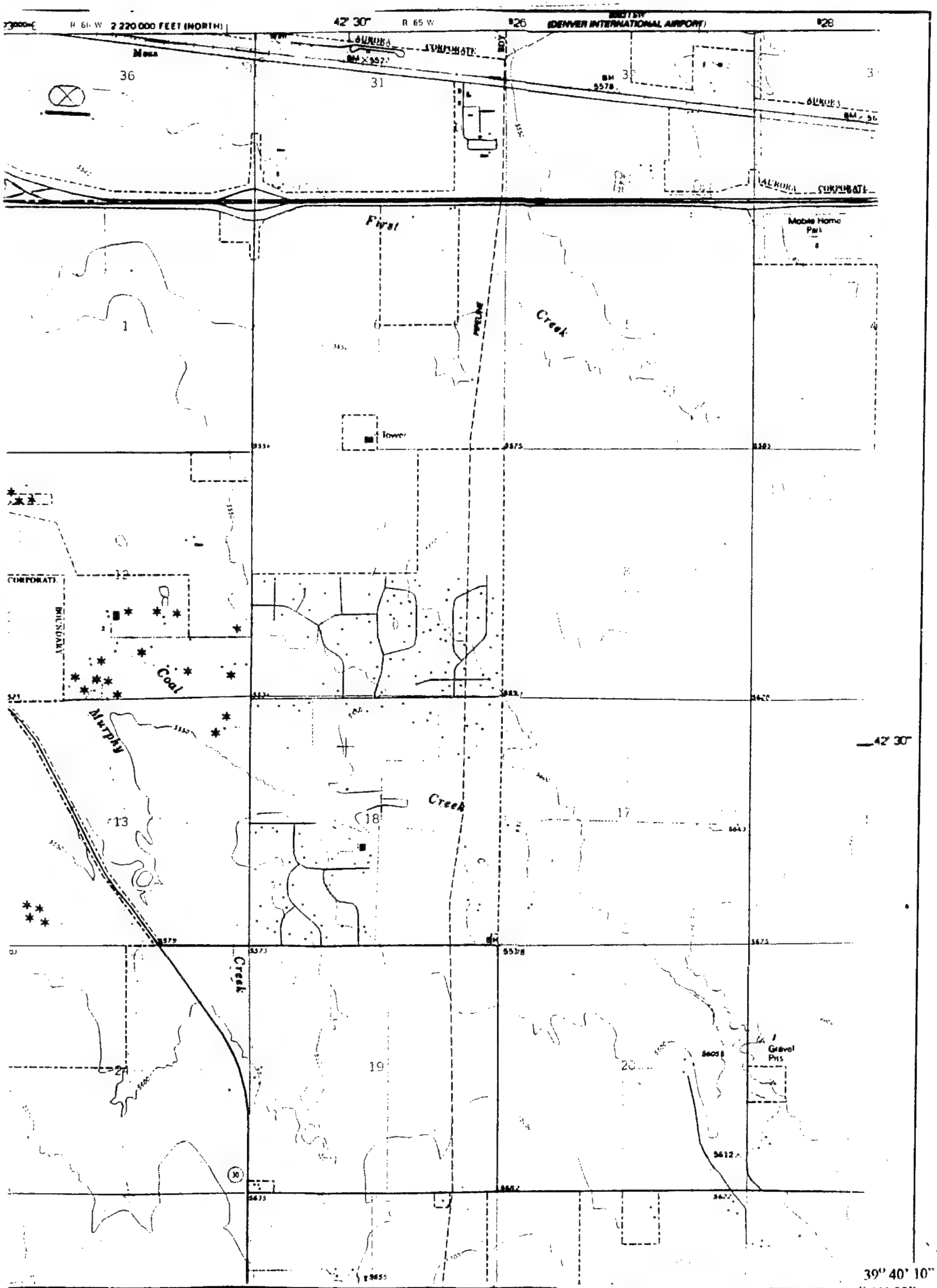

Figure 3-5

Topographic Map of Buckley ANGB and Surrounding Area Indicating locations of Municipal, Residential, and Agricultural Water Wells Within A One Mile Radius

★ USCWTP Monitoring Well

• Buckley ANGB Well

Coal Creek quadrangles

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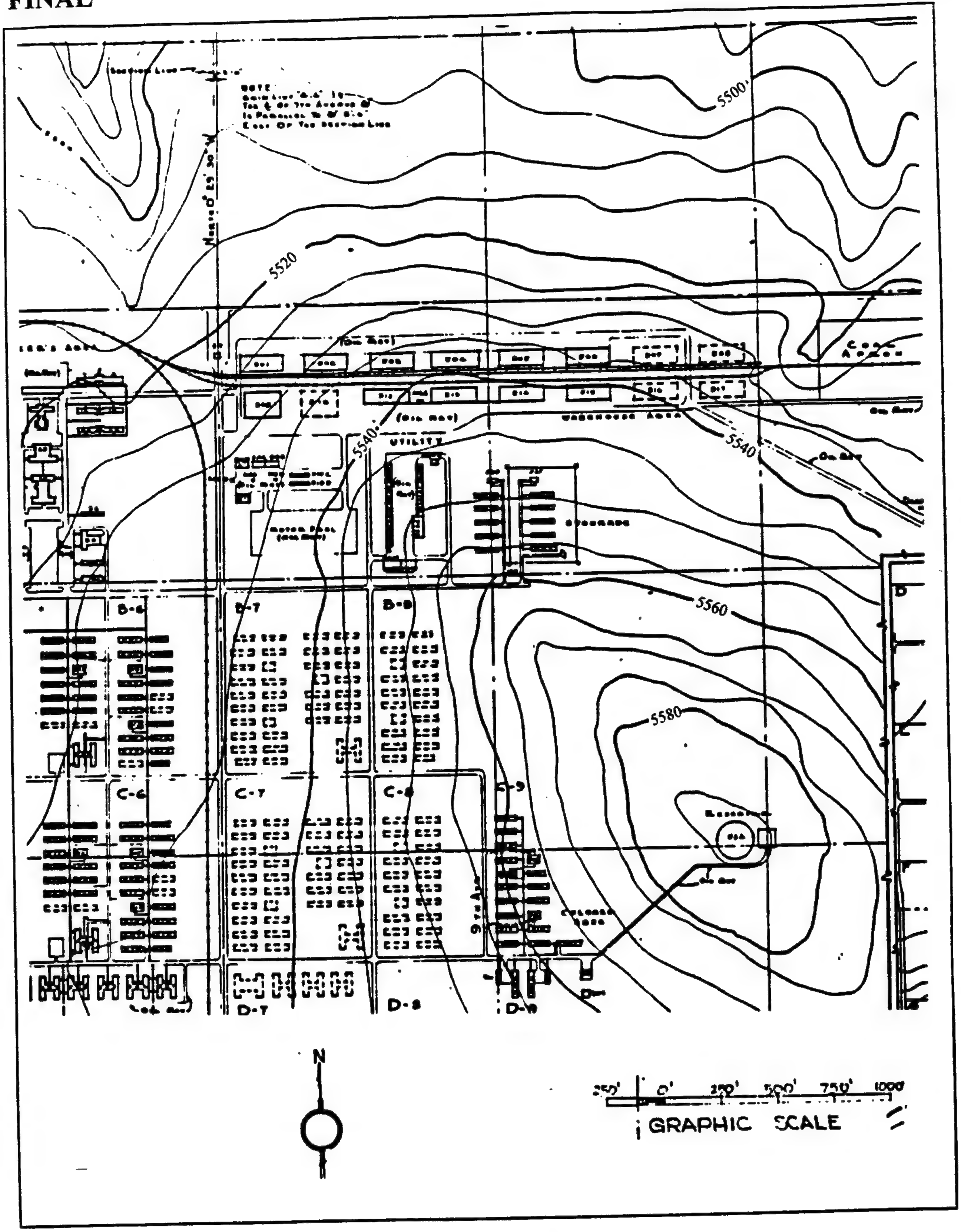

Figure 3-6
Historical Topography of the FWA (Buckley Field, 1942).

Historical Base maps indicated the presence of clay sewer lines within the FWA. The sewer lines serve the Former AF Motor Pool, the Former Naval Civil Engineering (CE) Utility Yard, the Former Naval Barracks/Stockade and the western portion of the Former Depot. The sewer system drained to the former sewage treatment plant at the northwest corner of the Buckley ANGB. The sewer system served latrines and certain buildings. It did not function as a storm sewer.

3.5 HYDROGEOLOGY

Three principle aquifers comprise the Denver Basin within the Buckley ANGB area. In descending order, these aquifers are the Denver, Arapahoe, and Laramie-Fox Hills aquifers. Confining layers of claystones and shales separate these aquifers by impeding vertical and horizontal groundwater flow caused by the lenticular shape of the sedimentary basin beds. Figure 3-7 presents a hydrogeologic stratigraphic column illustrating the principle aquifers within the Buckley ANGB area.

Variable consolidated sandstones, conglomerate, and siltstone sedimentary deposits of the Denver Formation comprise the Denver Aquifer. Both water table and confined conditions occur within the aquifer. Water table conditions generally exist where the Denver Formation outcrops or is overlain by alluvial or eolian deposits in the vicinity of Buckley ANGB. In the central portion of the Denver Basin, where the Denver Formation is overlain by the Dawson Arkose, confined conditions generally exist. Direct infiltration of precipitation, irrigation water in highland areas, and downward leakage in upland reaches of stream and river valley alluvial aquifers recharge the Denver aquifer. Groundwater discharge occurs as baseflow to local streams where the aquifer outcrops in valley areas. Significant amounts of groundwater are discharged to pumping wells and seep into the underlying Arapahoe Aquifer.

Groundwater within the Denver Aquifer flows radially outward from the center of the Denver Basin. Flow within the aquifer in the Buckley ANGB area is toward the South Platte River to the northwest where the aquifer outcrops. The river serves as a groundwater divide within the aquifer and serves as a major discharge area for the aquifer.

Regional hydraulic conductivity, storativity, and transmissivity values of the Denver Aquifer indicate it is a relatively poor producer of groundwater. A large thickness of the aquifer must be screened by a well to produce significant quantities of groundwater. Low amounts of groundwater are produced as a result of relatively impermeable fine grained sediments and the limited areal extent and lenticular structure of the water-producing rock units within the Denver Formation. However, a slightly higher hydraulic conductivity of 2×10^{-5} ft per second (ft/sec) (6×10^{-4} centimeters per second [cm/sec]) is reported in the general vicinity of the Buckley ANGB. Unconfined storativity values range from 0.09 to 0.33 and from 2×10^{-4} to 6×10^{-4} in confined portions of the aquifer. Transmissivity values are reported in the 375 gallons per day per foot (gpd/ft) range in the Base vicinity but are reported as high as 3,000 gpd/ft for the aquifer.

<table>
<tr><td rowspan="3">Denver Aquifer</td><td>Eolian Deposits</td></tr>
<tr><td>Alluvial Deposits</td></tr>
<tr><td>Denver Formation</td></tr>
<tr><td>Arapahoe Aquifer</td><td>Arapahoe Formation</td></tr>
<tr><td rowspan="2">Laramie-Fox Hill Aquifer</td><td>Laramie Formation</td></tr>
<tr><td>Fox Hill Sandstone</td></tr>
</table>

Figure 3-7
General Hydrogeological Stratigraphic Column for the Buckley ANGB

Alluvial deposits overlying the Denver Formation may also be important aquifers within the Buckley ANGB area. These deposits, which result from the erosion of upland bedrock areas, range in thickness of 20 to 100 ft and form the alluvial aquifer system. These aquifers are contained within stream and river valleys and exist under unconfined conditions due to the surficial settings and relatively coarse-grained composition. The aquifer is recharged by direct infiltration of precipitation and irrigation water and by lateral and upward seepage of groundwater in downstream reaches of valleys. The aquifer discharges groundwater through evapotranspiration, seepage to streams, downward seepage into underlying bedrock aquifers, and pumping wells.

Groundwater flow within the alluvial aquifer is toward and downgradient along stream channels. Hydraulic conductivity and storativity values are believed to be greater than the underlying bedrock aquifers due to the coarse-grained nature of the alluvial material. Transmissivity values increase with aquifer thickness and grain size and are likely greatest along the South Platte River.

The local water-bearing strata at the Buckley ANGB is composed primarily of the Denver Aquifer, the alluvial aquifer within stream areas, and the surficial aquifer contained within the eolian deposits. Based on previous investigations at the Base, the hydrogeologic system is very complex due to variations in thickness and areal extent of individual high and low permeable units (i.e., sands vs. clays and shales). The Denver Aquifer exists under both confined and semi-confined conditions due to variations in rock types and thickness. The alluvial aquifer occurs under unconfined conditions. The surficial aquifer within the eolian deposits is investigated as part of this FWA SI. No previous investigation information is available describing the characteristics of this aquifer. Aquifer conditions are believed to change from water table to confined conditions due to seasonal fluctuations in groundwater levels.

Results of the RI conducted at Buckley ANGB indicate that the local groundwater potentiometric surface generally follows land surface topography. Groundwater levels range 5432.73 ft above mean sea level (MSL) at Site 7-Former Sewage Treatment Plant to 5595.38 ft above MSL at background well BGW-2 located at the southeastern portion of the Base. Groundwater horizontal flow is generally to the northwest, reflecting the recharge effects of precipitation infiltration in the upland areas of the Base and the discharge of groundwater to Toll Gate Creek and Sand Creek. A downward vertical gradient exists at the Base, which is consistent with regional aquifer properties.

Aquifer slug tests conducted during the RI determined values of hydraulic conductivity ranging from 4×10^{-4} ft/sec (1.2×10^{-2} centimeters per second [cm/sec]) to 1×10^{-6} ft/sec (3.0×10^{-5} cm/sec). These values agree with regional values for the Denver Aquifer. Hydraulic conductivity values do not vary significantly within Base boundaries.

Local surficial groundwater directly north of the FWA investigation area is approximately 18 to 24 ft below ground surface (bgs) based on three monitoring wells installed at the Aurora USCWTP site. According to boring logs for these wells, groundwater exists within the upper portion of the Denver Formation and not the overlying eolian deposit (see Figure 3-8).

There are 1,895 recorded or permitted public and private wells within a 4-mile radius of the Base (Colorado State Engineer, Water Resources Branch,1996). Of these, 176 are monitoring wells.

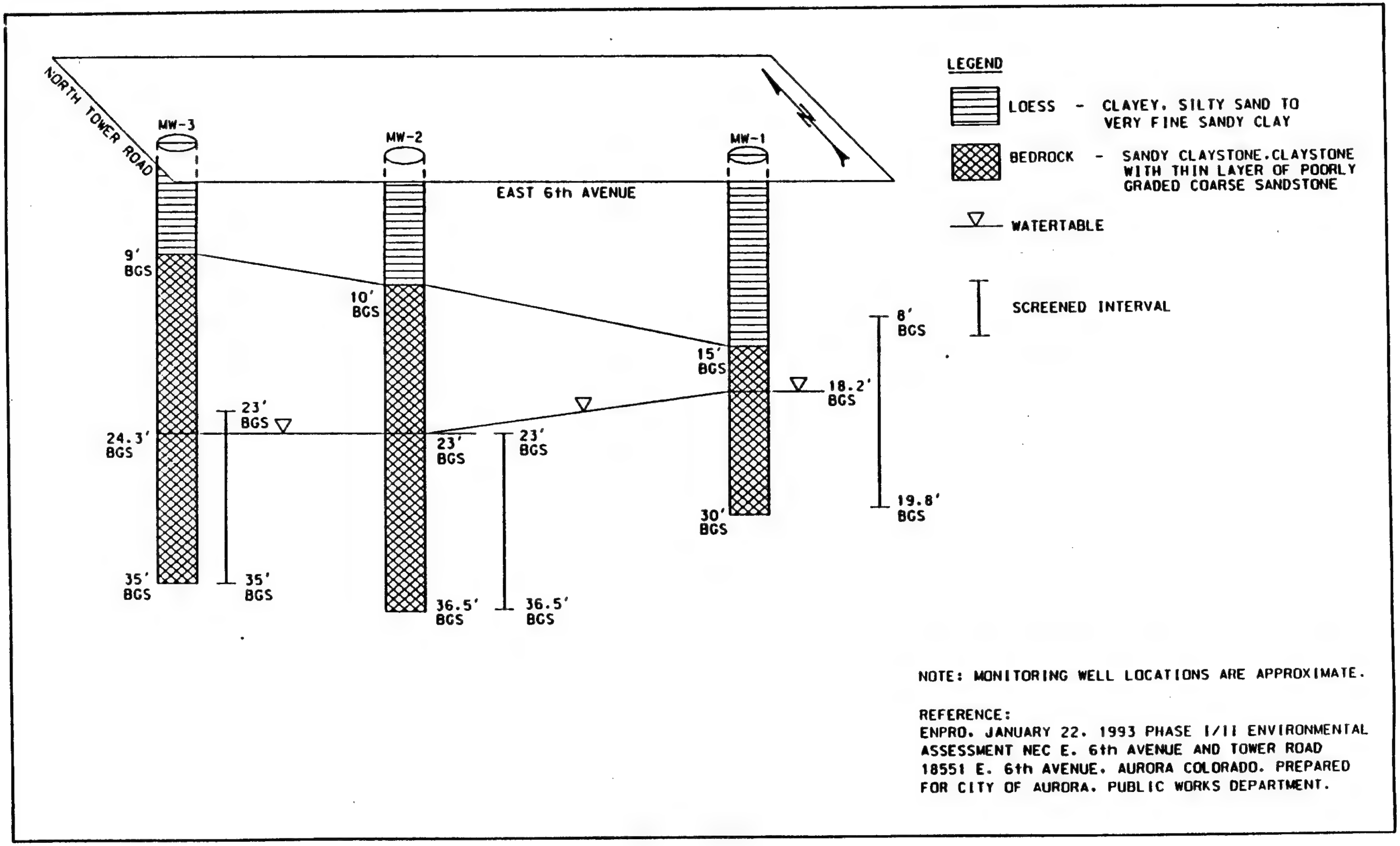

Figure 3-8
Hydrogeological Cross-Section of USCWTP Site Based on Phase I/II EA.
(See Figure 1-1 for location of monitoring wells relative to the Former Warehouse Area.)

The approximate locations of public and private water supplies within a 1-mile radius of the base are provided in Figure 3-5. Due to the large number of wells in the area, monitoring wells are not depicted on this map. There are 214 wells within a 1-mile radius of the Base. Of these, 186 are residential or agricultural wells, 21 are monitoring wells, and 7 are for municipal use. Water wells located on or associated with the Buckley ANGB are presented in Figure 3-9. Wells within a 1-mile radius of the Base range in depth from 45 to 2,186 ft.

3.6 CRITICAL HABITATS/ENDANGERED AND THREATENED SPECIES

Critical habitats and endangered and threatened species have been examined at Buckley during previous investigations. The findings of these investigations are summarized in the IRP Management Action Plan (MAP) (Radian Corporation, 1995). According to the IRP MAP critical habitats, which consist of unique or unusual natural settings that are necessary for the continuation and propagation of key species in an ecosystem, are not situated at or near Buckley ANGB. Wetland areas surrounding the Base consist of Cherry Creek State Park located approximately 1.5 miles to the southwest and Bluff Lake located 2.5 miles northwest of the Base.

Numerous threatened and endangered species reside within the Buckley ANGB area. A specific list of threatened species could not be found in Base documents reviewed during SI Work Plan preparation. Therefore, the Ecological Services Division of the Denver area United States Fish and Wildlife Service field office was contacted to obtain the current list of threatened species within the Buckley ANGB area (Appendix A). The response letter listed the following threatened and endangered species that could reside at or visit Buckley ANGB.

Birds: Bald eagle, *Haliaeetus leucocephalus*, Threatened

Mammals: Black-footed ferret, *Mustela nigripes*, Endangered

Plants: Ute ladies'-tresses orchid, *Spiranthes diluvialis*, Threatened

Federal candidate species that could occur at or visit Buckley ANBG include:

Birds: Mountain plover, *Charadrius montanus*

Mammals: Preble's meadow jumping mouse, *Zapus hudsonius preblei*
Swift fox, *Vulpes velox*

Plants: Colorado butterflyweed, *Gaura neomexicana ssp. Coloradensis*

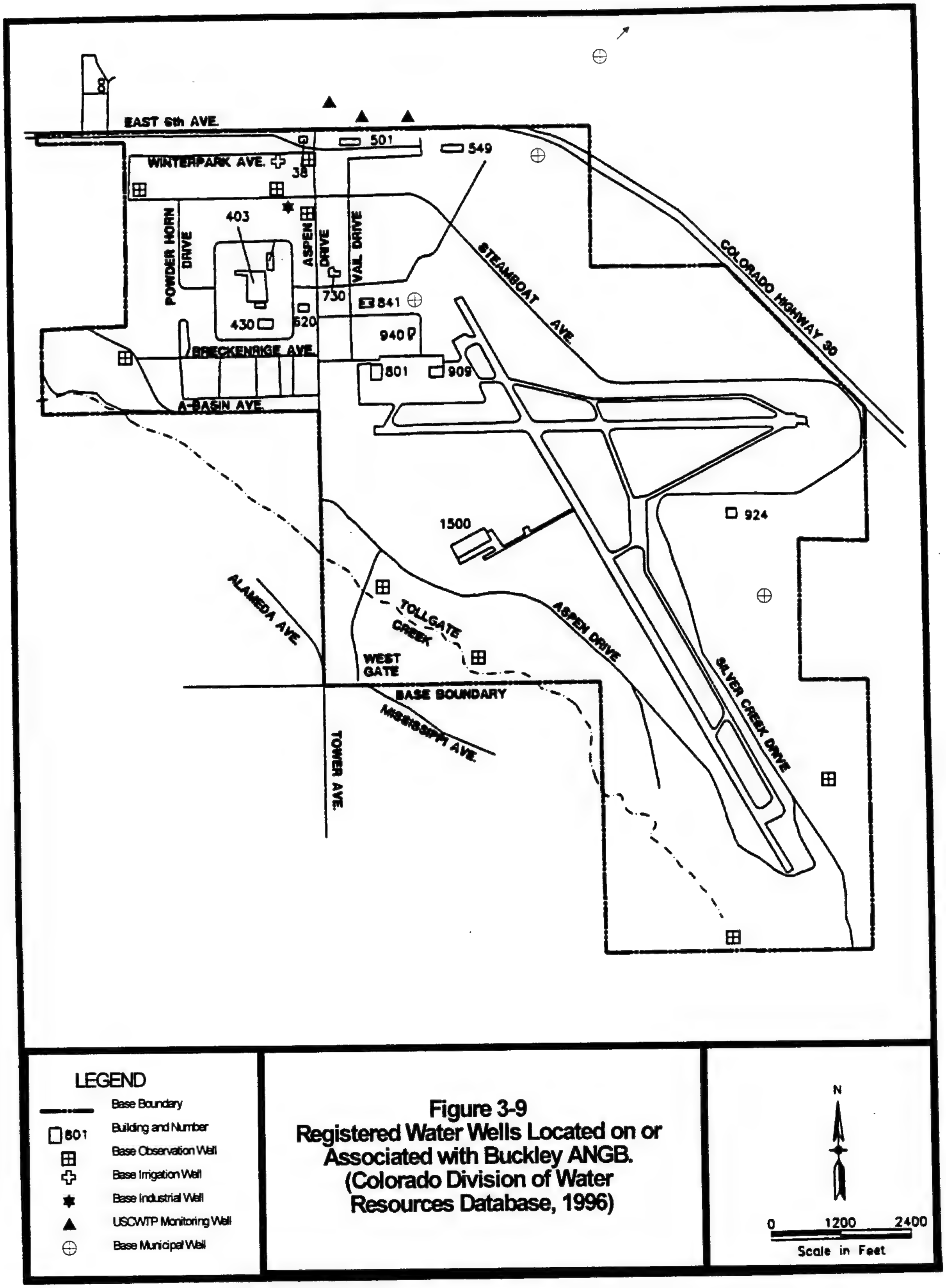

Figure 3-9
Registered Water Wells Located on or Associated with Buckley ANGB. (Colorado Division of Water Resources Database, 1996)

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4.0 FORMER WAREHOUSE AREA SITE EVALUATION

This section provides a description of the Buckley ANGB FWA. A description of historical activities conducted at the FWA is given and AOCs at the FWA are identified. Information is summarized from previous investigations (Enpro, 1993; SAIC, 1995), historical surveys (Powers Elevation Corporation, 1995), and the IRP MAP (Radian Corporation, 1995). Additional information was obtained from Buckley ANGB records and personnel while developing the FWA SI Work Plan.

4.1 WAREHOUSE AREA DESCRIPTION

The FWA is located near the northern base boundary along East 6th Avenue east of Aspen Drive directly south of the City of Aurora's USCWTP site (see Figure 4-1). The FWA is composed of four main areas: the Former Depot area, the Former AF Motor Pool, the Former Naval CE Utility Yard, and the Former Naval Barracks/Stockade. The SI focused on the Former Depot area and Former AF Motor Pool. The Former Naval CE Utility Yard and Former Naval Barracks/Stockade were evaluated during the scoping phase of the SI and were eliminated from investigation under the SI. A detailed map of the FWA is provided in Figure 4-1.

No environmental investigations have been conducted at the FWA prior to the SI. A preliminary review of Buckley ANGB records was conducted as part of the FWA SI Work Plan preparation. This review involved examining Base drawings and conducting two informal interviews with Buckley ANGB employees, which provided the majority of background information on the Former Depot area and Former AF Motor Pool.

4.1.1 Former Depot Area

The Former Depot area is located in the FWA's northern portion. Two east-west rows of seven warehouses comprised the depot. The warehouses were numbered 501 through 507, 509, 510, and 512 through 516. The warehouses were of temporary construction with slab concrete foundations. All warehouses have been demolished except for 510, 515, 516, and camper trailer park #48, which are scheduled for demolition. The two rows of warehouses were separated by three sets of railroad tracks. A former coal storage and wood pile area is located east of the depot where the three railroad spurs terminate. The railroad lines and coal pile have since been removed. A demolition debris pile and camper/trailer park currently occupy the former coal storage area. The camper/trailer units are stored in this area, unoccupied. A layer of recently disturbed soil currently exists on the ground surface in and around areas of demolished warehouses. Soil around the perimeters of Warehouses 510, 515, 516, and demolished Warehouses 506 and 507 appear to not have been disturbed by recent demolition activities.

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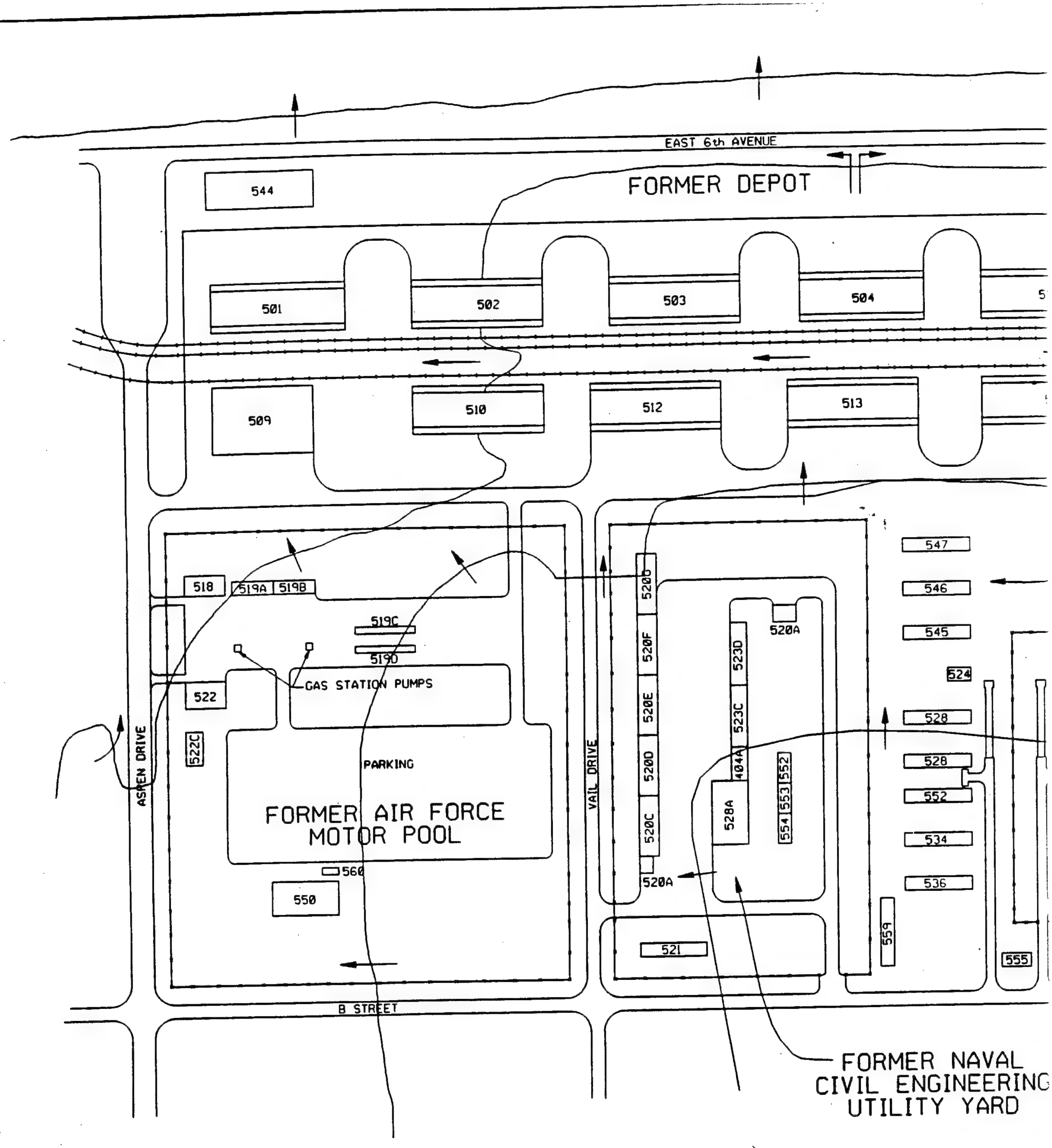
EAST 6th AVENUE
FORMER DEPOT
544
501
502
503
504
509
510
512
513
518
519A
519B
519C
519D
GAS STATION PUMPS
522
522C
ASPEN DRIVE
PARKING
FORMER AIR FORCE
MOTOR POOL
560
550
B STREET
VAIL DRIVE
520B
520F
520E
520D
520C
520A
523D
523C
404A
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FORMER NAVAL
CIVIL ENGINEERING
UTILITY YARD

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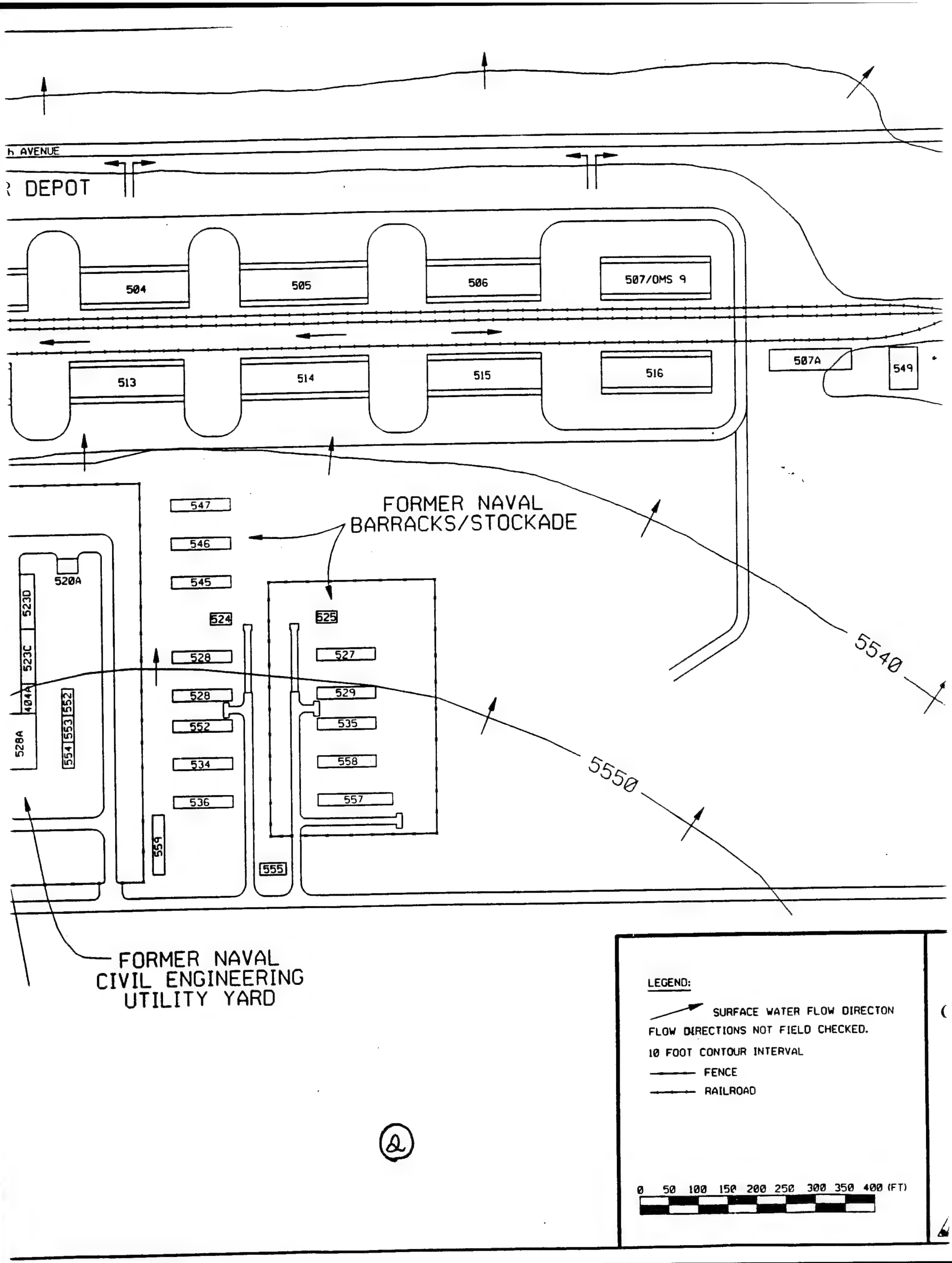
h AVENUE
DEPOT
504
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507/OMS 9
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507A
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FORMER NAVAL BARRACKS/STOCKADE
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523D
523C
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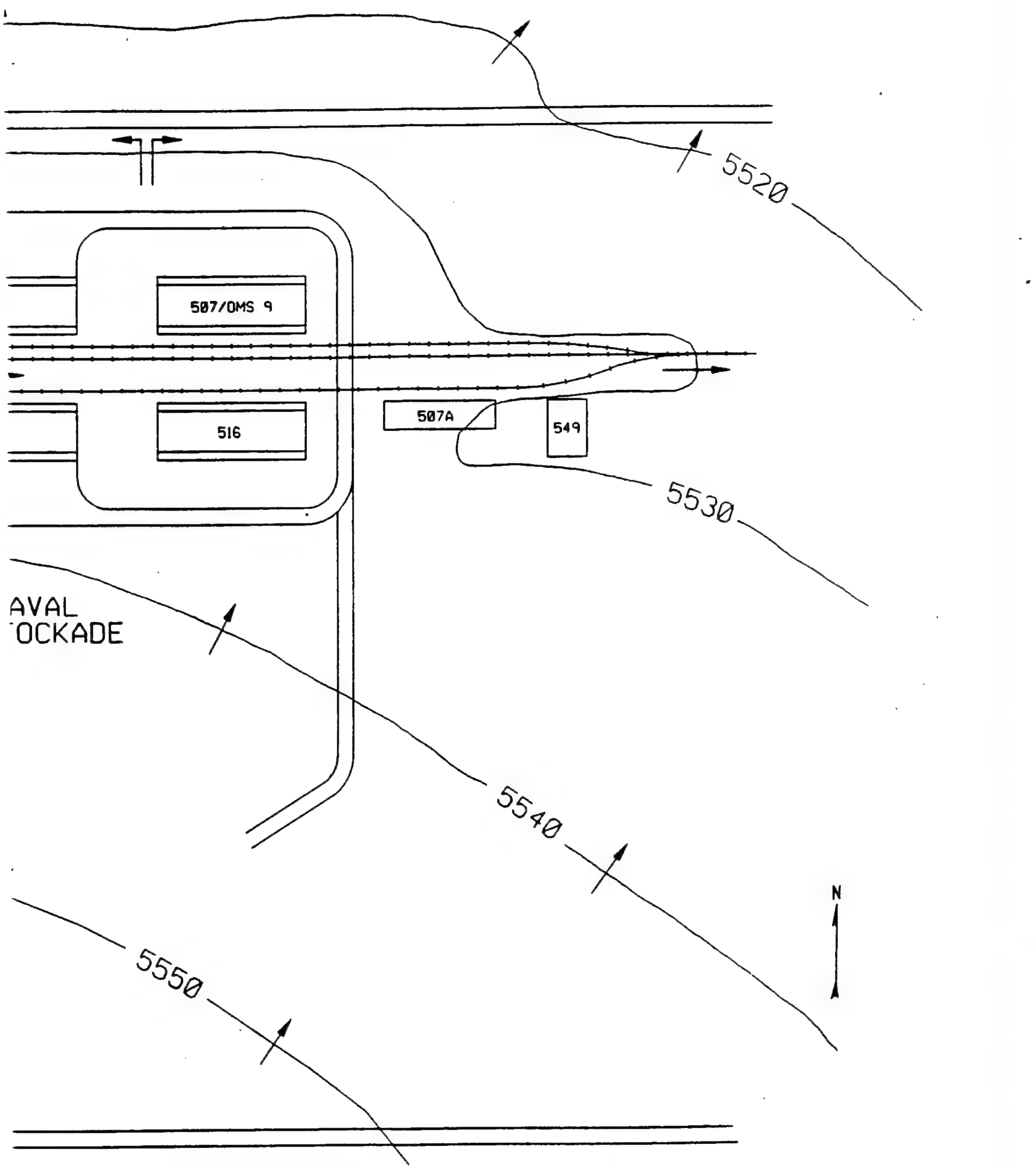
FORMER NAVAL CIVIL ENGINEERING UTILITY YARD
LEGEND:
SURFACE WATER FLOW DIRECTON
FLOW DIRECTIONS NOT FIELD CHECKED.
10 FOOT CONTOUR INTERVAL
FENCE
RAILROAD
0 50 100 150 200 250 300 350 400 (FT)
2



LEGEND:

SURFACE WATER FLOW DIRECTON

FLOW DIRECTIONS NOT FIELD CHECKED.

10 FOOT CONTOUR INTERVAL

FENCE

RAILROAD

3

0 50 100 150 200 250 300 350 400 (FT)

Figure 4-1

General Map of Former Warehouse Area

SITE TOPOGRAPHY
APPROXIMATED FROM USGS
FITZSIMMONS QUADRANGLE, 1994

FORMER WAREHOUSE AREA
SITE INVESTIGATION
BUCKLEY AIR NATIONAL GUARD BASE

STONE & WEBSTER ENGINEERING CORPORATION
DENVER, COLORADO

DRAWING NUMBER 4-3

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The eastern side of the Former Depot area, including Warehouses 505 through 507 and 514 through 516 are closest to and potentially upgradient of the USCWTP property where groundwater contaminants were discovered.

The 12 warehouses of the Former Depot area were originally used to store and distribute Base equipment and supplies. Supplies were delivered to the Base via railroad and stored in the warehouses. Motor vehicles used to distribute supplies were loaded from the warehouses from the opposite side of the railroad tracks. Each warehouse had side entrances (east and west) where motor vehicles could enter from the loading dock surrounding each warehouse.

Some of the warehouses were modified as their uses changed; Warehouse 501 was converted into administration offices, Warehouse 513 became the warehouse management office, and Warehouse 507 was converted to Organization Maintenance Shop (OMS) 9.

OMS 9, in the northeast corner of the Former Depot area, was owned and operated from approximately 1955 to January 1996 by the Army National Guard. Light vehicle maintenance activities, such as oil and transmission fluid changes, were performed in this building. The OMS serviced between 350 to 400 government vehicles stationed within the Denver metro area. Vehicles were washed to remove mud and dirt on the east side of the building or at an adjacent fire hydrant. Engine cleaning operations were not performed at this location. From 1985 until closure in 1996, cleaning solvents and used oils were recycled or disposed of by Buckley ANGB using an outside contractor.

Pesticide and/or herbicide spraying operations were staged from Warehouse 506 between approximately 1985 to 1995.

Prior to 1985, a pipe stuck in the ground on the north side of Warehouse 505 reportedly was used to dispose of waste oil and organic cleaning fluids. Wastes were poured into the pipe. This pipe could not be located during a recent site visit because Warehouse 505 has been recently demolished. It is unknown whether the alleged pipe drained to a dry well, UST, sewer line, or some other buried structure. A review of Buckley ANGB records did not indicate the presence of USTs or sewer lines in the immediate vicinity of Warehouse 505.

Former Depot Area AOC

Identified AOCs at the Former Depot area consist of the following:

- The area surrounding and beneath Warehouse 507/OMS 9 where vehicle maintenance and chemicals may have been stored;
- The area surrounding and beneath Warehouse 506 where potential chemicals may have been stored;
- The area surrounding and beneath Warehouse 505 where potential chemicals may have been stored and were allegedly disposed of; and

- The former location of railroad tracks that existed between the warehouses where chemicals may have been spilled.

4.1.2 Former AF Motor Pool

The Former AF Motor Pool was operated from the early 1940's to 1957. Motor vehicles were repaired and maintained at this location. The area consisted of two motor repair shops (Buildings 518 and 522) and gasoline pumps. Several other buildings existed within the area. However, their use is unknown. Building 522 contained classrooms and offices. All structures within the Former AF Motor Pool have been demolished.

According to Buckley ANGB records, the Former AF Motor Pool contained two 10,000-gallon gasoline USTs. These tanks fed three fuel pumps. Two of the fuel pumps existed within the boundaries of the motor pool area. The third pump was located north of the motor pool area along the east-west road, which is between the motor pool and Former Depot. A site walk-over, conducted as part of the SI Work Plan preparation to locate fuel pumps and storage tanks, was inconclusive. On-site observations indicate that available Base drawings do not match the layout of observed features.

It was reported during the SI Kickoff Meeting that the two USTs in later years were used to store waste oils or bulk fuel for subsequent incineration at the Base. However, base personnel interviewed stated that bulk fuel oil was stored in USTs elsewhere on the Base and was periodically pumped and transported to the power stations to be used as fuel.

<u>Former AF Motor Pool AOC</u>

Identified AOCs at the Former Motor Pool area consist of the following:

- The two 10,000-gallon USTs that contained gasoline and may have been used for bulk or waste fuel storage;
- Pipelines associated with the UST and fuel pumps; and
- Former motor repair shops (Buildings 518 and 522) where chemicals may have been used.

5.0 FIELD PROGRAM

Under the direction of the ANGRC and Air Force National Guard Bureau, Stone & Webster implemented the SI field program, which included a geophysical survey, soil borings using Geoprobe® equipment and installation of piezometers and monitoring wells. Groundwater, soil, and soil gas sampling and analysis activities were also conducted. Field SI activities followed the Final Former Warehouse Area Site Investigation Work Plan, prepared by Stone & Webster for the National Guard Bureau, dated October 4, 1996. The SI Work Plan also contained a Site Specific Quality Assurance Project Plan (SSQAPP) and a Site Specific Health and Safety Plan (SSHSP). The SSQAPP was based on the Stone & Webster Generic Quality Assurance Project Plan (GQAPP), dated September 1994, developed for and approved by the National Guard under Contract DAHA90-94-D-0008.

The following subsections describe the site-specific procedures, rationale, and methods that were used by Stone & Webster and it subcontractors during the FWA SI activities.

5.1 GENERAL APPROACH

For efficiency, tasks were executed in sequence; information obtained from each task was utilized in subsequent tasks. The primary tasks completed for this investigation included: (1) a geophysical survey; (2) a soil gas survey; (3) soil borings with soil sampling; (4) piezometer installations; (5) monitoring well installations; (6) groundwater sampling; and (7) aquifer testing.

The Base records search, conducted as part of the SI Work Plan preparation, allowed the field effort to focus on potential source areas. These areas are the Former AF Motor Pool area and the Former Depot area in the vicinity of former Warehouses 505, 506, and 507/OMS 9. The geophysical survey located potential subsurface source(s) (e.g., USTs) to aid in accurately locating soil gas and soil boring sampling locations. The soil gas survey identified areas with elevated levels of VOCs commonly associated with impacted soil and/or groundwater. Soil borings were placed at potential sources and in areas of high VOC soil gas readings to collect soils for contaminant characterization and confirmation. Piezometers were installed to determine groundwater flow directions and gradients, to aid in optimally locating monitoring wells, and to collect samples to characterize groundwater. Monitoring wells were located up and downgradient of suspected source areas to characterize groundwater and to evaluate the impact of source areas on groundwater. The upgradient wells will provide background data for comparison purposes to assist in determining the impact of source areas on groundwater. Monitoring wells were not located in known COPC source areas. Slug tests conducted on piezometers and monitoring wells determined hydraulic characteristics of the aquifer.

5.2 PIEZOMETER/MONITORING WELL INSTALLATION AND SAMPLING

The original FWA SI Work Plan required the design and installation of monitoring wells and piezometers to be identical, although their functions would differ. Piezometers were to be used to determine groundwater levels and flow directions, but not for groundwater sampling. Monitoring wells, which were positioned based on the results of groundwater flow directions from the piezometer measurements, were to be used exclusively for groundwater sampling. However, due to the absence of significant groundwater within the surficial aquifer across the FWA, several monitoring well locations failed to encounter groundwater. The presence of hydraulically "tight" silts and clays resulted in little to no groundwater produced at several monitoring well locations. Therefore, it was necessary to sample several piezometers to adequately evaluate groundwater conditions. This was an acceptable substitution because all piezometers and monitoring wells were identically designed and installed.

All piezometer and monitoring well borings were completed using HSA techniques. Borings were drilled until either the approved depth was reached or groundwater was encountered. A total of 13 HSA soil borings were drilled during the course of the FWA SI. Six of these borings were converted to piezometers (i.e., FWAPZ01 through FWAPZ06), four of the soil borings were converted to monitoring wells (i.e., FWAMW03, FWAMW04, FWAMW06, and FWAMW07), and three borings originally planned for monitoring wells (i.e., FWAMW01, FWAMW02, and FWAMW05) were plugged and abandoned due to the lack of significant groundwater production in the boring. The optional fourteenth boring was not drilled. Surface soil samples were collected for laboratory analysis from background monitoring well borings. Following borehole completion, the piezometer or monitoring well screen and casing were installed in the borehole. The installed piezometers and monitoring wells were then developed to prepare for groundwater sampling. Well logs detailing installation are provided in Appendix F.

5.2.1 Soil Borings and Soil Sampling Associated with Monitoring Well and Piezometer Installation

All borings were completed using HSA techniques and soil classification was completed in accordance with the GQAPP. Continuous soil core samples were collected while drilling, and a sample was collected for headspace field screening of total VOCs. Soil samples were visually analyzed to describe soil stratigraphy and collected for total VOC headspace field screening analysis.

Two surficial background soil samples (i.e., FWASB21-00 and FWASB22-00) were collected from the two upgradient monitoring well boring locations, FWAMW05 and FWAMW01, respectively. These samples were collected from a depth of 0 to 6 inches bgs using a stainless steel hand trowel. These surficial background soil samples were analyzed for VPHs, EPHs, VOCs, SVOCs, chlorinated pesticides/herbicides, and 13 Priority Pollutant (PP) metals (i.e., antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc).

At each boring, the soil stratigraphy was logged visually from the continuous core sample for soil type, grain size, and color. Soils were classified according to the Unified Soil Classification System and described according to ASTM D2488-69 "Description of Soils." A soil sample was collected every 5 ft and analyzed for total VOC headspace. Each photographed soil core is presented in Appendix C.

Drill cuttings were screened with a MiniRae® photoionization detector (PID) for total VOCs. The PID had a detection limit of approximately 1.0 ppm. All soil samples and drill cuttings with total VOC readings greater than 5 parts per million (ppm) were containerized. Uncontaminated soil samples and drill cuttings were separated from contaminated soils and spread on the ground at the drilling location.

5.2.2 Soil Headspace Screening

A PID was used to analyze soil headspace gas of soil samples collected during the HSA drilling of boreholes for piezometers and monitoring wells. Total VOC headspace analysis screening of collected soil samples was accomplished by placing the selected portion of each sample into a clean 8-oz. glass jar that allows for 50 percent headspace, covering the mouth of the jar with aluminum foil, screwing the lid onto the jar, and allowing the soil temperature to equilibrate to ambient air temperature for approximately 10 minutes. During periods of cold conditions, the jars were placed on the dash board of the field vehicle to facilitate warming. Headspace vapor measurements were obtained by inserting the tip of the PID through a small hole in the jar lid and through the foil cover. The maximum PID reading was recorded. Soil headspace readings are presented on the boring logs (see Appendix B) and on the geological cross sections (see Figures 6-2 through 6-7, Section 6). The PID was calibrated daily as discussed in Section 10 of the SSQAPP and calibration readings were recorded in the field calibration notebook.

5.2.3 Monitoring Well/Piezometer Installation

All soil borings encountering groundwater were completed as piezometers or monitoring wells. Piezometers were drilled and installed prior to monitoring wells. Groundwater level measurements obtained from the piezometers were used to determine local groundwater flow direction and gradients to optimize the placement of the monitoring wells. Monitoring wells were positioned to permit accurate collection and analysis of groundwater samples. Data were used to characterize and determine the extent of potential groundwater COPC within the shallow aquifer at the FWA. Specific monitoring well and piezometer design is discussed below.

Six piezometers were installed at locations specified in the FWA SI Work Plan. Four monitoring wells were completed downgradient of COPC areas within the Former AF Motor Pool area and at the Former Depot area in the vicinity of former Warehouses 505, 506, and 507/OMS 9. All piezometer and monitoring wells, except for piezometer FWAPZ04, were completed as water table wells, meaning wells were installed with the well screen straddling the water table. Piezometer FWAPZ04 was initially installed as a water table well, based on the boring's lithology.

Subsequently, the most recent groundwater level measurement (1/12/97) indicated that the water level within the piezometer rose approximately 4 ft above the top of the well screen.

All piezometers and monitoring wells were constructed of 2-inch, Schedule 40, polyvinyl chloride (PVC) riser with flush-threaded joints. Each piezometer and monitoring well was constructed with a 10-ft long slotted PVC well screen, 10-slot (0.010-inch). The bottom of each monitoring well and piezometer was sealed with a screw-on PVC end cap. The top of each piezometer and well was completed with a slip-on vented PVC well cap.

A primary filter sand pack was placed around the screen to a height of approximately 2 ft above the screen. An annular seal, consisting of between 2 to 3 ft of pure bentonite clay, was placed above the sand pack. All annular seals, composed of bentonite chips, were placed above the water table and were hydrated with approximately 5 gallons of potable water according to the manufacturer's specifications.

A cement-bentonite grout was installed above the bentonite seal to within 3 ft bgs. The cement-bentonite mixture consisted of portland cement (ASTM CISO) and potable water in the proportion of not more than 7 gallons of clean water per bag of cement (1 cubic ft or 94 pounds). Additionally, 3 percent by weight bentonite powder was added per cubic foot of cement. A side discharging tremie pipe was used to place the cement-bentonite grout atop the annular seal to avoid its disruption.

Surface completion of monitoring wells and piezometers was constructed to prevent tampering, entrance of foreign material into the well, and damage from frost heaving. All piezometers and monitoring wells at the FWA were completed above grade. A 5-ft length of protective outer steel casing was installed and set approximately 2 ft into a concrete pad placed around the well. A 2 ft by 2 ft concrete pad, constructed around the protective casing and sloped away from the well, extends below the frost line. A weep hole was to be placed near the bottom of the protective casing but above the concrete pad. All piezometers and wells are locked with keyed-alike brass padlocks to prevent unauthorized access.

Three brightly painted steel guard posts were installed around each piezometer and monitoring well. These 6 ft posts, equally spaced around the piezometer or well outside of the concrete pad, are buried at least 3 ft into the ground. Each post was filled and set in with concrete.

Groundwater levels were accurately measured from each piezometer and monitoring well. To ensure consistent readings, a small notch was placed on the rim at the top of the well casing. This notch is clearly marked with a permanent marker with an arrow drawn on the outside of the well casing pointing to the notch. Depth to groundwater measurements and top of casing (TOC) elevation were surveyed from this notch.

No unnecessary water was added to the borehole, piezometer, or monitoring well during installation. Five gallons of potable water was added to each boring to hydrate the bentonite chip annular seal.

5.2.4 Monitoring Well Development

Development of piezometers and monitoring wells was conducted from November 1 to 17, 1996. Development is performed to remove fines and create a good hydraulic contact between the well screen and surrounding filter sand pack. This was accomplished by using either a 12-volt submersible pump with dedicated hose or a dedicated bailer to remove water from each piezometer or well. Acids, dispersing agents, or explosives were not used. Development began no earlier than 24 hours following well completion to allow the bentonite seal and bentonite-grout to set properly. Development for some piezometers and wells was initiated prior to installing the protective surface casing and concrete pad. No water was introduced into the piezometers or wells during development.

Development of both piezometers and monitoring wells was complicated by the low hydraulic conductivity of the shallow aquifer. As a result, all piezometers and monitoring wells became dry following the removal of a single borehole volume. Subsequently, development consisted of purging dry each piezometer and monitoring well several times over a several-day period while monitoring field parameters (i.e., conductivity, pH, and temperature). Development was continued until the purge water was visibly clear and the water quality parameters had stabilized. At least three borehole volumes of water plus the volume of water added during bentonite seal hydration were removed during purging.

Development of piezometer FWAPZ04 was extremely difficult due to the slow hydraulic recovery. Approximately 0.5 gallons of water were removed from the piezometer for each development event.

Following final development of the piezometer or monitoring well, approximately 8 ounces of water was collected from the well in a clear glass jar. This jar was labeled and photographed to document the water's clarity. These photographs are presented in Appendix C.

5.2.5 Groundwater Sampling

Two rounds of groundwater sampling were performed. Groundwater samples were collected on November 19 and December 13, 1996. The same piezometers and monitoring wells were sampled for each round for the same analytical parameters. Table 5-1 presents the analytical test parameters for each piezometer and monitoring well.

All piezometers and monitoring wells were purged prior to sampling. Due to the low hydraulic conductivity and resultant slow recovery rates, all sampled piezometers and monitoring wells were purged on the day prior to sampling. This allowed adequate time for well recovery to permit the

Table 5-1 Groundwater Analytical Parameters									
	Piezometers/Monitoring Wells								
Parameter (water)	**PZ1**	**PZ4**	**PZ5**	**MW3**	**MW4**	**MW6**	**MW7**	**MW8 (duplicate of MW3 - both sampling rounds)**	**Trip Blank**
8010/8020 (VOCs)	x	x	x	x	x	x	x	x	x
8270 (SVOCs)	x	x	x	x	x	x	x	x	
8015M (VPH)	x	x	x	x	x	x	x	x	
8100M (EPH)	x	x	x	x	x	x	x	x	
8080 (Pesticides)	x	x		x				x	
8150 (Herbicides/Poly-chlorinated biphenyls)	x	x		x				x	
PP Metals (filtered)	x	x	x	x	x	x	x	x	
PP Metals (unfiltered)	x	x	x	x	x	x	x	x	
Field Parameters (pH, conductivity, dissolved O_2, and temperature)	x	x	x	x	x	x	x	x	

Note: PP Metals = Priority Pollutant Metals (antimony, arsenic, beryllium, cadmium, chromium, copper lead, mercury, nickel, selenium, silver, thallium, and zinc)

collection of the full amount of required water samples from each piezometer and monitoring well during a single sampling event. However, piezometer FWAPZ04 recovered very slowly and required resampling over several days to obtain the required sample volume. Purging consisted of pumping or bailing each piezometer or monitoring well dry. Groundwater field parameters (pH, temperature, and specific conductance) were measured during well purging. Because the piezometer and monitoring wells were purged dry, "fresh" formation water recharged to the well/piezometer overnight, allowing for sampling on the following day.

Groundwater samples were collected using two mechanisms, an electric pump and a bailer. A 12-volt submersible electric pump was one method used to purge and sample groundwater. A dedicated PVC hose was used to deliver water from the submersible pump to the surface at each well. The pump and hose assembly was used to collect all groundwater parameters except VOCs. Disposable bailers were used to collect VOC groundwater samples and to purge piezometer FWAPZ04. A disposable bailer was dedicated to each sampled piezometer and well. A disposable bailer was also used to collect all groundwater samples from piezometer FWAPZ04, because the water level in the piezometer was too deep to allow use of the submersible pump.

Groundwater was transferred directly from the pump and hose assembly or bailer to clean sample containers supplied by the laboratory. Filtered and unfiltered groundwater samples were collected at each piezometer and monitoring well for analysis of dissolved and total metals, respectively. All dissolved groundwater metals samples were filtered using a disposable inline 0.45 micron filter connected to the submersible pump discharge line. The dissolved metals sample from piezometer FWAPZ04 was filtered immediately upon receipt at the analytical laboratory. Water samples for VOC analysis were collected with zero headspace. Samples were labeled, packed on ice, and transported to the laboratory under proper chain-of-custody procedures. Sample handling procedures were followed as detailed in Section 8 of the SSQAPP. Field notes compiled during well development, purging, and sampling are documented in the field notebook.

Preserved and unpreserved VOC water samples were collected for each groundwater sample. A concern was raised by the CDPHE that carbonates within the groundwater would react with the hydrochloric acid preservative and form bubbles within the VOC samples. To ensure against this possibility, if bubbles subsequently formed in the preserved samples, a set of unpreserved VOC samples were simultaneously collected and held for analysis. Subsequently, bubble formation within the preserved VOC water samples was not reported by field sampling or laboratory personnel.

5.2.6 Groundwater Level Data Collection

Two sets of static groundwater level measurements were obtained from all FWA SI piezometers and monitoring wells. Measurements were taken on December 12, 1996 and January 17, 1997. The first round of measurements were obtained immediately prior to beginning well purging for the second groundwater sampling round. The second round of measurements were taken approximately 1 month following completion of the second groundwater sampling round. The very

slow recovery rate of piezometer FWAPZ04 caused groundwater level measurements to be postponed. This delay allowed groundwater levels to stabilize and generated data that more accurately represented groundwater levels. Groundwater levels were also obtained during development, purging, and sampling activities; however, usefulness of the data in interpreting groundwater levels at the FWA is limited because all piezometer and monitoring wells exhibited slow recovery rates. Groundwater levels obtained during the well recovery are not representative of natural levels at the FWA.

Groundwater measurements were obtained from the TOC notch in piezometers and monitoring wells using an electronic water level indicator. For each water level measurement, the electronic water level indicator was lowered and raised to the groundwater surface a minimum of three times to confirm groundwater depth before recording the measurement. The water level indicator used to measure the static water level (SWL) was graduated in 0.01-ft increments. The probe and tape of the selected measuring device was decontaminated before and after each use. Each round of piezometer and monitoring well groundwater level measurements was completed within a 1-hour period.

5.2.7 Aquifer Testing

Rising head slug tests were performed on all piezometers and monitoring wells installed during the investigation, following the first round of groundwater sampling. Slug testing consisted of displacing a known volume of water within the well by a slug ballast, which was lowered into the monitoring well. The water level was allowed to equilibrate to initial conditions, then the ballast was quickly raised from the well. The water level recovery within the well was recorded with an electronic data logger using a level-type pressure transducer. The well time-drawdown recovery data were analyzed to obtain aquifer hydraulic conductivity values.

Because only water table conditions were encountered at all monitoring wells and piezometers during the period of testing, only rising head slug tests are applicable.

5.2.8 Geophysical Survey

Electromagnetic and magnetic geophysical surveys were conducted on October 17, 1996 at the FWA to locate potential underground COPC sources. Specifically, these geophysical techniques were utilized to locate USTs, fuel pumps, and other potential metallic sources in the Former AF Motor Pool and to locate an alleged dry well and pipe on the north side of Warehouse 505 located in the Former Depot area.

The electromagnetic (EM) surveys were completed using a Geonics EM-61 time-domain metal detector. The EM-61 was operated in the wheel mode with data collected on 5 ft line spacings (east to west) and 0.65-ft station spacings (north to south).

The electromagnetic method is a geophysical technique based on the physical principles of inducing and detecting electrical current flow within geologic strata. A receiver detects these induced currents by measuring the resulting time-varying magnetic field. The electromagnetic method measures bulk conductivity (the inverse of resistivity) of geologic materials beneath the transmitter and receiver coils. In the electromagnetic method, currents are induced by the application of time-varying magnetic fields.

Electromagnetics can be used to locate pipes, utility lines, cables, buried steel drums, trenches, buried waste, and concentrated contaminant plumes. The method can also be used to map shallow geologic features, such as lithologic changes and fault zones.

Magnetic (Mag) surveys were completed using a Geometrics Model 858 Cesium magnetometer with a line spacing of 5 ft (east to west) and station spacings at 0.3-second intervals (north to south), which is approximately one reading every foot at normal walking speed. The Mag sensor was maintained approximately 6 ft above the ground for the duration of the survey.

A magnetometer is an instrument that measures magnetic field strength. Local variations, or anomalies, in the earth's magnetic field are the result of disturbances caused mostly by variations in concentrations of ferromagnetic material in the vicinity of the magnetometer's sensor. A buried ferrous object, such as a steel drum or tank, locally distorts the earth's magnetic field and results in a magnetic anomaly. The objective of conducting a magnetic survey at a hazardous waste or groundwater pollution site is to map these anomalies and delineate the area containing buried sources of the anomalies.

After analyzing magnetic data an operator can estimate the aerial extent of buried ferrous targets, such as a steel tank or drum. Furthermore, areas of burial can be prioritized with high priority areas indicating a near certainty of buried ferrous material. In some instances, estimates of depth of burial can be made from the data.

Separate geophysical survey grids were established at the Former AF Motor Pool and in the vicinity of Warehouse 505 within the Former Depot area. Horizontal control for the Former AF Motor Pool geophysical surveys was achieved by using a 200-ft tape measure to establish a square grid, using the fences along the northern and western boundaries of the area and historical building corners. Geophysical lines and appropriate fiducial markers were laid out on this grid. The Former AF Motor Pool grid was 400 ft in the east-west direction and 300 ft in the north-south direction.

Survey control at Warehouse 505 consisted of a grid measuring 300 ft in the east-west direction and 170 ft in the north-south direction. EM or Mag surveys were not required within the foundation limits of the former Warehouse 505.

At both surveyed areas, each 10-ft line was marked along the north and south baseline with pin flags to enable the operator to stay on line; fiducial lines were marked at half the north-south

distance to confirm locations along each line. This grid layout allowed the operator to estimate between the 10-ft markers for the intermediate 5-ft line spacings.

Additional detailed information on the operations of the EM and Mag methods and interpretation of data is presented in Appendix D.

5.2.9 Soil Gas Survey

VOCs within either soils or groundwater that migrate through the pores of the unsaturated soil zone can be detected using soil gas survey techniques. A soil gas survey and mapping were conducted at the FWA to identify potential VOC contaminant source areas within soil and groundwater. Biogenic gases, oxygen (O_2) and carbon dioxide (CO_2) were analyzed to assess the degree of biological degradation. The soil gas survey was conducted between October 23 to November 1, 1996. A total of 200 soil gas sampling locations were established, sampled, and analyzed. Sixty soil gas samples were collected at the Former AF Motor Pool area and 140 soil gas samples were collected from the Former Depot within the vicinity of Former Warehouses 505, 506, and 507. All soil gas samples were field analyzed in a mobile laboratory for VOCs (SW-846 method 8240) utilizing a gas chromatograph and mass spectrometer (GC/MS). Percent O_2 and CO_2 were also analyzed using a gas chromatograph.

Initial and follow-up soil gas samples were obtained. Initial soil gas sampling locations were selected and presented in the FWA SI Work Plan. Thirty-six and 53 initial soil gas locations were selected at the Former AF Motor Pool and Former Warehouses 505, 506, and 507, respectively. Subsequent follow-up soil gas sampling locations were determined in the field, based on the results of the initial soil gas samples and follow-up soil gas samples. Subsequent soil gas sampling attempted to delineate the extent of soil gas VOCs within each study area.

A separate sampling grid was established at the Former AF Motor Pool and Former Warehouses 505, 506, and 507 areas using wooden stakes and a tape measure. Each grid was established based on the physical features at each location. Each soil gas sampling point was staked and coordinates determined based on the established sampling grid. A computer was used to tabulate and graphically plot each soil gas sample field screening result to evaluate the distribution of soil gas concentrations at each site as sampling and analysis progressed.

Soil gas samples were obtained using Geoprobe® sampling methods. All soil gas samples were obtained in the same manner by collecting soil gas samples through a hollow steel rod and probe assembly. The assembly was mechanically driven into the ground to a depth of approximately 5 ft bgs but above the water table. Initially proposed soil gas sampling locations for both the Former AF Motor Pool and the Former Depot were predetermined by the SI Work Plan. Subsequent soil gas locations were chosen in the field, based on results from the initial soil gas locations.

After driving the rod and probe assembly to the sample depth, a specially constructed stainless-steel and Teflon® connection with sampling hose was threaded onto the top of the rod. The rod was then

raised approximately 3 to 6 inches, leaving the disposable aluminum probe tip in the ground. The assembly was then attached to a vacuum pump and purged with several volumes of soil gas. When purging was completed, the sampling assembly was connected directly to a glass bulb sampler. One end of the bulb was connected to the Teflon® sampling hose and the other to the vacuum pump. The bulb was then purged using the vacuum pump for a period of 5 minutes. The valves on both ends of the bulb are closed and the bulb disconnected from the Teflon® sampling hose and the vacuum pump to complete sampling. The glass bulb was immediately returned to the field laboratory for analysis.

For the purpose of assessing COPC within the USTs at the Former AF Motor Pool, one soil gas sample (i.e., SG192) was obtained directly from the west UST. This was accomplished by inserting a sampling hose through a small hole in the manhole cover of the UST and extracting air within the tank using the soil gas sampling assembly.

The glass bulbs used for sampling were made of an analytically clean, glass and non-porous polymer, designed for high purity gas sampling. Each glass bulb was equipped with a valve at each end for connection to the sampling assembly and a septum. Samples for VOC analysis are extracted from the glass bulb through the septum with a syringe and immediately injected into the field laboratory GC/MS. Samples for O_2 and CO_2 measurements were also sampled directly from the glass bulbs, using a GC for analysis, and the maximum readings were recorded. All field monitoring instruments were calibrated daily.

5.2.10 Soil Boring Samples

Twenty soil borings were drilled to collect soil samples to characterize the FWA soils. Soil borings were located in suspected contaminant source areas identified by the preliminary review of Buckley ANGB records conducted as part of the preparation of the SI Work Plan, and identified by results of the geophysical and soil gas surveys. Soil borings were also used to identify FWA lithology.

Twenty soil borings were drilled within the Former Depot and Former AF Motor Pool areas between October 30 and November 6, 1996. Eight borings were located at the Former AF Motor Pool area with half of these located around the perimeter of the USTs. The remaining four borings were located within areas of elevated soil gas VOCs. Twelve borings were drilled at the Former Depot around the perimeter of former Warehouses 505, 506, and 507/OMS 9.

Soil samples were collected using direct push Geoprobe® soil sampling procedures. Three soil samples were collected from each boring from the top, middle, and bottom of the unsaturated soil column. Continuous core samples were collected from four borings. The top or surface soil sample was collected from the top 6 inches of native soil. Samples were collected in 4-ft sections from the land surface to refusal or bedrock, whichever occurred first. The water table depth was not readily discernible due to the presence of clays and silts that did not transmit significant quantities of groundwater to clearly indicate the presence of groundwater.

The maximum boring depth was 34 ft bgs at soil boring FWASB01a. Sampling equipment was damaged from very tight silts and clays during this boring. As a result, all remaining borings were completed to a maximum depth ranging from 14 to 28 ft bgs, depending upon local refusal.

A total of 60 soil samples were collected and analyzed from the soil borings. All soil samples were analyzed for VOCs, SVOCs, VPHs, EPH, and PP metals. In addition, 12 soil samples collected from the four soil borings around the perimeter of Former Depot Warehouse 506 were analyzed for chlorinated pesticides, herbicides, and PCBs. A search of the Buckley ANGB records indicated that the use, storage, or disposal of pesticides and herbicides may have occurred at that location. Six blind duplicate soil samples were collected in conjunction with these samples. Soil headspace screening was not required for the direct push soil boring samples. A summary of all collected soil boring samples and associated QC samples are presented in Table 5-2.

Four continuous soil core samples were collected to characterize site lithology, three were collected within the Former Depot, and one at the Former AF Motor Pool areas. Soil samples were obtained from the soil core samples for laboratory analyses.

5.3 BACKGROUND SOIL SAMPLING

Two background soil samples were obtained from the two upgradient monitoring well boring locations (FWAMW01 and FWAMW02). These samples, collected from a depth of 0 to 6 inches bgs, were analyzed for VOCs, SVOCs, VPHs, EPHs, PP metals, chlorinated pesticides, herbicides, and PCBs. A summary of these samples is presented in Table 5-2.

5.4 INVESTIGATION-DERIVED WASTES

Three types of investigation-derived wastes (IDW) were produced during the field portion of the FWA SI. These wastes included water from equipment decontamination, water produced during purging/developing of monitoring wells and piezometers, and soil from HSA and direct push drill cuttings.

Characterization of these wastes was conducted as part of the FWA SI. Characterization of the liquid and solid IDWs was based on analytical results of groundwater and soil samples collected during the FWA SI. The IDW was also characterized by analyzing water and soil samples collected directly from drums containing IDW. Appendix E contains a letter report to the ANG detailing characterization findings and disposal recommendations. This information is summarized below.

Table 5-2
Summary of Soil Boring Samples

Sample Number	Sample Location	Sample Depth (ft)	Date/Time		Analysis
FWASB01-00	North side of USTs, Former AF Motor Pool	0 to 0.5	10/30/96	1515	VOC, SVOCs, PPM, VPH, EPH
FWASB01-12	North side of USTs, Former AF Motor Pool	12 to 15	10/30/96	1600	VOC, SVOCs, PPM, VPH, EPH
FWASB01-32	North side of USTs, Former AF Motor Pool	32 to 34	11/01/96	1500	VOC, SVOCs, PPM, VPH, EPH
FWASB02-00	East side of USTs, Former AF Motor Pool	0 to 0.5	11/04/96	0725	VOC, SVOCs, PPM, VPH, EPH
FWASB02-10	East side of USTs, Former AF Motor Pool	10 to 12	11/04/96	0740	VOC, SVOCs, PPM, VPH, EPH
FWASB02-20	East side of USTs, Former AF Motor Pool	20 to 24	11/04/96	0755	VOC, SVOCs, PPM, VPH, EPH
FWASB03-00	South side of USTs, Former AF Motor Pool	0 to 0.5	11/04/96	0845	VOC, SVOCs, PPM, VPH, EPH
FWASB03-08	South side of USTs, Former AF Motor Pool	8 to 10	11/04/96	0900	VOC, SVOCs, PPM, VPH, EPH
FWASB03-16	South side of USTs, Former AF Motor Pool	16 to 18	11/04/96	0915	VOC, SVOCs, PPM, VPH, EPH
FWASB04-00	West side of USTs, Former AF Motor Pool	0 to 0.5	11/04/96	0940	VOC, SVOCs, PPM, VPH, EPH
FWASB04-09	West side of USTs, Former AF Motor Pool	9 to 11	11/04/96	0945	VOC, SVOCs, PPM, VPH, EPH
FWASB04-18	West side of USTs, Former AF Motor Pool	18 to 20	11/04/96	1000	VOC, SVOCs, PPM, VPH, EPH
FWASB05-00	Soil gas 023, Former AF Motor Pool	0 to 0.5	11/06/96	1005	VOC, SVOCs, PPM, VPH, EPH
FWASB05-08	Soil gas 023, Former AF Motor Pool	8 to 10	11/06/96	1010	VOC, SVOCs, PPM, VPH, EPH
FWASB05-16	Soil gas 023, Former AF Motor Pool	16 to 18	11/06/96	1020	VOC, SVOCs, PPM, VPH, EPH
FWASB06-00	Soil gas 028, Former AF Motor Pool	0 to 0.5	11/06/96	0915	VOC, SVOCs, PPM, VPH, EPH
FWASB06-08	Soil gas 028, Former AF Motor Pool	8 to 10	11/06/96	0920	VOC, SVOCs, PPM, VPH, EPH
FWASB06-16	Soil gas 028, Former AF Motor Pool	16 to 18	11/06/96	0945	VOC, SVOCs, PPM, VPH, EPH
FWASB07-00	Soil gas 146, Former AF Motor Pool	0 to 0.5	11/06/96	0830	VOC, SVOCs, PPM, VPH, EPH
FWASB07-09	Soil gas 146, Former AF Motor Pool	9 to 11	11/06/96	0840	VOC, SVOCs, PPM, VPH, EPH
FWASB07-18	Soil gas 146, Former AF Motor Pool	18 to 20	11/06/96	0900	VOC, SVOCs, PPM, VPH, EPH
FWASB08-00	Soil gas 006, Former AF Motor Pool	0 to 0.5	11/06/96	1045	VOC, SVOCs, PPM, VPH, EPH
FWASB08-08	Soil gas 006, Former AF Motor Pool	8 to 10	11/06/96	1055	VOC, SVOCs, PPM, VPH, EPH
FWASB08-16	Soil gas 006, Former AF Motor Pool	16 to 18	11/06/96	1105	VOC, SVOCs, PPM, VPH, EPH
FWASB09-00	Soil gas 149, Former Depot Warehouses	0 to 0.5	11/04/96	1050	VOC, SVOCs, PPM, VPH, EPH
FWASB09-14	Soil gas 149, Former Depot Warehouses	14 - 16	11/04/96	1110	VOC, SVOCs, PPM, VPH, EPH
FWASB09-18	Soil gas 149, Former Depot Warehouses	18 - 20	11/04/96	1134	VOC, SVOCs, PPM, VPH, EPH

Table 5-2 (continued)
Summary of Soil Boring Samples

Sample Number	Sample Location	Sample Depth (ft)	Date/Time		Analysis
FWASB10-00	Soil gas 179, Former Depot Warehouses	0 to 0.5	11/04/96	1405	VOC, SVOCs, PPM, VPH, EPH
FWASB10-09	Soil gas 179, Former Depot Warehouses	9 to 14	11/04/96	1415	VOC, SVOCs, PPM, VPH, EPH
FWASB10-18	Soil gas 179, Former Depot Warehouses	18 to 20	11/04/96	1455	VOC, SVOCs, PPM, VPH, EPH
FWASB11-00	Soil gas 104, Former Depot Warehouses	0 to 0.5	11/04/96	1530	VOC, SVOCs, PPM, VPH, EPH
FWASB11-09	Soil gas 104, Former Depot Warehouses	9 to 12	11/04/96	1535	VOC, SVOCs, PPM, VPH, EPH
FWASB11-18	Soil gas 104, Former Depot Warehouses	18 to 20	11/04/96	1555	VOC, SVOCs, PPM, VPH, EPH
FWASB12-00	Soil gas 162, Former Depot Warehouses	0 to 0.5	11/05/96	0840	VOC, SVOCs, PPM, VPH, EPH
FWASB12-12	Soil gas 162, Former Depot Warehouses	12 to 13	11/05/96	0905	VOC, SVOCs, PPM, VPH, EPH
FWASB12-18	Soil gas 162, Former Depot Warehouses	18 to 19.5	11/05/96	0925	VOC, SVOCs, PPM, VPH, EPH
FWASB13-00	Soil gas 066, Former Depot Warehouses	0 to 1.0	11/05/96	0950	VOC, SVOCs, PPM, VPH, EPH, Pest, Herbicides
FWASB13-09	Soil gas 066, Former Depot Warehouses	9 to 12	11/05/96	1010	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
FWASB13-17	Soil gas 066, Former Depot Warehouses	17 to 19	11/05/96	1040	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
FWASB14-00	Soil gas 126, Former Depot Warehouses	0 to 0.5	11/05/96	1215	VOC, SVOCs, PPM, VPH, EPH
FWASB14-08	Soil gas 126, Former Depot Warehouses	8 to 10	11/05/96	1155	VOC, SVOCs, PPM, VPH, EPH
FWASB14-16	Soil gas 126, Former Depot Warehouses	16 to 18	11/05/96	1210	VOC, SVOCs, PPM, VPH, EPH
FWASB15-00	Soil gas 111, Former Depot Warehouses	0 to 0.5	11/05/96	1430	VOC, SVOCs, PPM, VPH, EPH
FWASB15-08	Soil gas 111, Former Depot Warehouses	8 to 10	11/05/96	1445	VOC, SVOCs, PPM, VPH, EPH
FWASB15-16	Soil gas 111, Former Depot Warehouses	16 to 18	11/05/96	1500	VOC, SVOCs, PPM, VPH, EPH
FWASB16-00	Soil gas 081, Former Depot Warehouses	0 to 0.5	11/06/96	1520	VOC, SVOCs, PPM, VPH, EPH
FWASB16-06	Soil gas 081, Former Depot Warehouses	6 to 8	11/06/96	1530	VOC, SVOCs, PPM, VPH, EPH
FWASB16-12	Soil gas 081, Former Depot Warehouses	12 to 14	11/06/96	1540	VOC, SVOCs, PPM, VPH, EPH
FWASB17-00	Soil gas 133, Former Depot Warehouses	0 to 0.5	11/06/96	1430	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
FWASB17-06	Soil gas 133, Former Depot Warehouses	6 to 8	11/06/96	1435	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
FWASB17-12	Soil gas 133, Former Depot Warehouses	12 to 14	11/06/96	1445	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides

Table 5-2 (continued)
Summary of Soil Boring Samples

Sample Number	Sample Location	Sample Depth (ft)	Date/Time		Analysis
FWASB18-00	Soil gas 071, Former Depot Warehouses	0 to 0.5	11/06/96	1450	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
FWASB18-06	Soil gas 071, Former Depot Warehouses	6 to 8	11/06/96	1500	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
FWASB18-12	Soil gas 071, Former Depot Warehouses	12 to 14	11/06/96	1515	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
FWASB19-00	Soil gas 046, Former Depot Warehouses	0 to 0.5	11/06/96	1335	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
FWASB19-06	Soil gas 046, Former Depot Warehouses	6 to 8	11/06/96	1345	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
FWASB19-12	Soil gas 046, Former Depot Warehouses	12 to 14	11/06/96	1415	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
FWASB20-00	Soil gas 109, Former Depot Warehouses	0 to 0.5	11/06/96	1250	VOC, SVOCs, PPM, VPH, EPH
FWASB20-08	Soil gas 109, Former Depot Warehouses	8 to 10	11/06/96	1300	VOC, SVOCs, PPM, VPH, EPH
FWASB20-16	Soil gas 109, Former Depot Warehouses	16 to 18	11/06/96	1315	VOC, SVOCs, PPM, VPH, EPH
FWASB21-00	Surface Background @ FWAMW05	0 to 0.5	11/08/96	1040	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
FWASB22-00	Surface Background @ FWAMW01	0 to 0.5	11/08/96	1105	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
FWASB30-20	Duplicate of FWASB02-20	20 to 24	11/04/96	0850	VOC, SVOCs, PPM, VPH, EPH
FWASB31-09	Duplicate of FWASB10-09	9 to 14	11/04/96	1600	VOC, SVOCs, PPM, VPH, EPH
FWASB32-09	Duplicate of FWASB13-09	9 to 12	11/05/96	0850	VOC, SVOCs, PPM, VPH, EPH
FWASB33-00	Duplicate of FWASB07-00	0 to 0.5	11/06/96	0825	VOC, SVOCs, PPM, VPH, EPH
FWASB34-00	Duplicate of FWASB06-00	0 to 0.5	11/06/96	0820	VOC, SVOCs, PPM, VPH, EPH
FWASB35-00	Duplicate of FWASB08-00	0 to 0.5	11/06/96	1015	VOC, SVOCs, PPM, VPH, EPH
EB2-041196	Equipment blank #2	na	11/04/96	1630	VOC, SVOCs, PPM, VPH, EPH
FB1-050096	Field Blank #1	na	11/05/96	1705	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides
EB3-051196	Equipment blank #3	na	11/05/96	1715	VOC, SVOCs, PPM, VPH, EPH Pest, Herbicides

Table 5-2 (continued)
Summary of Soil Boring Samples

Note: Methods:
SW-846 8010/8020 VOC
SW-846 8270 SVOC
SW-846 8015M VPH
SW-846 8100M EPH
SW-846 8080 Pesticides
SW-846 8150 Herbicides/PCBs
EPA 200.7, 245.1/7470, 206.2, 239.2, 270.2, and 279.2 PP metals

Development and purge water from four monitoring wells (i.e., FWAMW03, FWAMW04, FWAMW06, and FWAMW07) and one piezometer (i.e., FWAPZ05) were retained as IDW. Analyses of groundwater from these locations were used to characterize these wastes. Results of these analyses were compared against regulatory limits in 40 CFR §261.24. Purge water from FWAMW03, FWAMW04, and FWAPZ05 exceeds the criteria for selenium (1.0 mg/l); FWAMW06 and FWAMW07 exceed the TCLP level for both selenium and lead (5.0 mg/l); and FWAMW04 exceeds the TCLP for tetrachloroethene (0.7 mg/l). These analytical results indicate that all drums containing purge water contain hazardous waste.

Five drums containing soil cuttings from monitoring wells FWAMW01 and FWAMW02, piezometer FWAPZ05, direct push soil cuttings, and from decontamination pad soils were analyzed for TCLP VOCs, SVOCs, and metals to determine IDW characterization. Barium and lead were detected below TCLP regulatory criteria. No other TCLP compounds were reported in these soils.

One drum of decontamination water used in cleaning drilling equipment was analyzed for flashpoint, halogenated and aromatic VOCs, and metals. Flashpoint and all concentrations of reported compounds were found to be below the City of Aurora wastewater discharge limits.

Management and disposal of these wastes depends on the level of contaminants, and upon federal, state and local regulations. If levels of contamination that cause the waste to be regulated as a hazardous waste are detected, disposal within 90 days of receiving analytical results is required. Disposal of IDW is Buckley ANGB's responsibility.

5.5 SURVEY OF SAMPLING LOCATIONS

All soil borings, piezometers, and monitoring well locations were surveyed. The horizontal and vertical position of these locations were surveyed by a state-registered surveyor to a horizontal accuracy of 0.1 ft and a vertical accuracy of 0.01 ft. Two survey events were conducted. Survey data are presented are Appendix J.

The first survey determined the relative horizontal and vertical position of newly installed FWA piezometers. The geodetic coordinates of piezometers were determined by a global positioning system and elevations were determined by differential leveling. These survey data were used in determining the piezometric surface and flow directions of the surficial aquifer. Information on flow direction was then used to determine locations of FWA monitoring wells.

The second survey conducted during the FWA SI determined the permanent horizontal and vertical locations of all FWA SI soil borings, piezometer, and monitoring wells. Coordinates were based on modified state plane coordinates (Colorado Central Zone). A brass disk survey marker at the north end of Runway 14 was used as the elevation control for each of the surveyed locations.

5.6 DEVIATIONS FROM WORK PLAN

The low hydraulic conductivity of the surficial aquifer and site lithology caused several deviations from the FWA SI Work Plan. These deviations included abandoning of well borings, deepening well borings, and modifying well development, purging, and sampling techniques.

The FWA SI Work Plan required monitoring wells and piezometers to be screened within the first occurrence of groundwater. If a water-bearing zone was encountered or if the maximum drill depth of the boring was reached, the boring was monitored for 24 hours to determine if the boring "yields water." The boring was drilled deeper than its maximum planned depth if no significant groundwater was encountered. Borings for monitoring wells FWAMW01 and FWAMW05 were drilled to the maximum planned depth of 39 ft bgs and failed to yield water. As a result, monitoring wells were not installed in these borings and, instead, the borings were plugged and abandoned in accordance with state-approved procedures.

In order to establish an upgradient background well, the borehole of piezometer FWAPZ04 was drilled beyond the originally planned depth of 39 ft bgs. This boring was drilled to a depth of 39 ft bgs on Friday November 1, 1996. By Monday, November 4, this borehole did not produce water and was extended to a depth of 49 ft bgs. By November 12, the boring contained approximately 2.5 ft of water. The borehole was drilled an additional 5 ft to a total depth of 54 ft bgs and a piezometer was installed with its screen straddling the water table. Unfortunately, groundwater within the piezometer continued to slowly recover over time until the water level rose above the top of the well screen.

The boring for monitoring well FWAMW02 was abandoned at 15 ft bgs due to the occurrence of solid bedrock at this depth. Competent bedrock was not anticipated such a shallow depth at the FWA SI area. Drilling through solid bedrock was beyond the investigation's scope. As a result, monitoring well FWAMW02 was not installed and the borehole was plugged and abandoned in accordance with state requirements.

The FWA SI Work Plan required installing and sampling seven monitoring wells. Due to site lithology and hydrogeologic characteristics, only four of seven monitoring wells were installed. However, to meet the groundwater sampling requirements of the Work Plan, three piezometers were incorporated into the groundwater sampling program. These piezometers, were FWAPZ01, FWAPZ04, and FWAPZ05. Piezometer wells were originally planned to determine only groundwater levels and are identified as piezometers for clarification purposes. Because the piezometers were designed and installed identically as monitoring wells at the FWA, their use for groundwater sampling is acceptable.

The low hydraulic conductivity of the shallow aquifer did not allow a sufficient recharge rate to piezometers and monitoring wells to allow development or purging without depleting the water within the well casing and surrounding sandpack. All monitoring wells and piezometers purged dry following the removal of one boring volume. As a result, development consisted of purging each piezometer or monitoring well dry a minimum of four and a maximum of seven times,

allowing time for the well to recharge following each purging. Generally, development consisted of purging each piezometer dry once a day while measuring field parameters.

Because of the low hydraulic conductivity of the shallow aquifer, when preparing each monitoring well and piezometer for sampling each well was purged dry instead of removing a minimum of three well casing volumes. The piezometer and monitoring wells were allowed to recover overnight to permit sufficient groundwater recovery to meet sample volume requirements for the required analyses. Groundwater recovery of piezometer FWAPZ04 was extremely slow. As a result, groundwater sampling of this piezometer was completed over a 6-day period to allow sufficient recovery to meet sample volume requirements within the required sample holding times.

The SI Work Plan required total petroleum hydrocarbon (TPH) analysis of water and soil samples by SW-846 method 8015M. Samples were analyzed by both SW-846 methods 8015 (VPHs) and 8100 (EPHs). TPH is equivalent to the sum of VPHs and EPHs. Method 8015 (VPH) analyzes lighter gasoline range hydrocarbons. Heavier diesel range hydrocarbons are analyzed by method 8100 (EPH). The SI Work Plan only required the analysis of petroleum hydrocarbons by method 8015. By analyzing samples with both methods, a clearer distinction between light and heavy petroleum components is provided.

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6.0 INVESTIGATION RESULTS

6.1 FORMER WAREHOUSE AREA GEOLOGY AND HYDROGEOLOGY

The primary purposes of the FWA SI were to determine the presence of COPC within the shallow soil of the FWA and determine the impact, if any, to the surficial aquifer. As a result, 33 soil borings were drilled, and six piezometers and four monitoring wells were installed, sampled, and hydraulically tested as part of the FWA SI. Information on the local geology and hydrogeology of the FWA has been obtained from these investigation activities. Boring logs are presented in Appendix B. Appendix F contains piezometer and monitoring well construction diagrams. Aquifer slug testing results are presented in Appendix G.

6.1.1 Geology

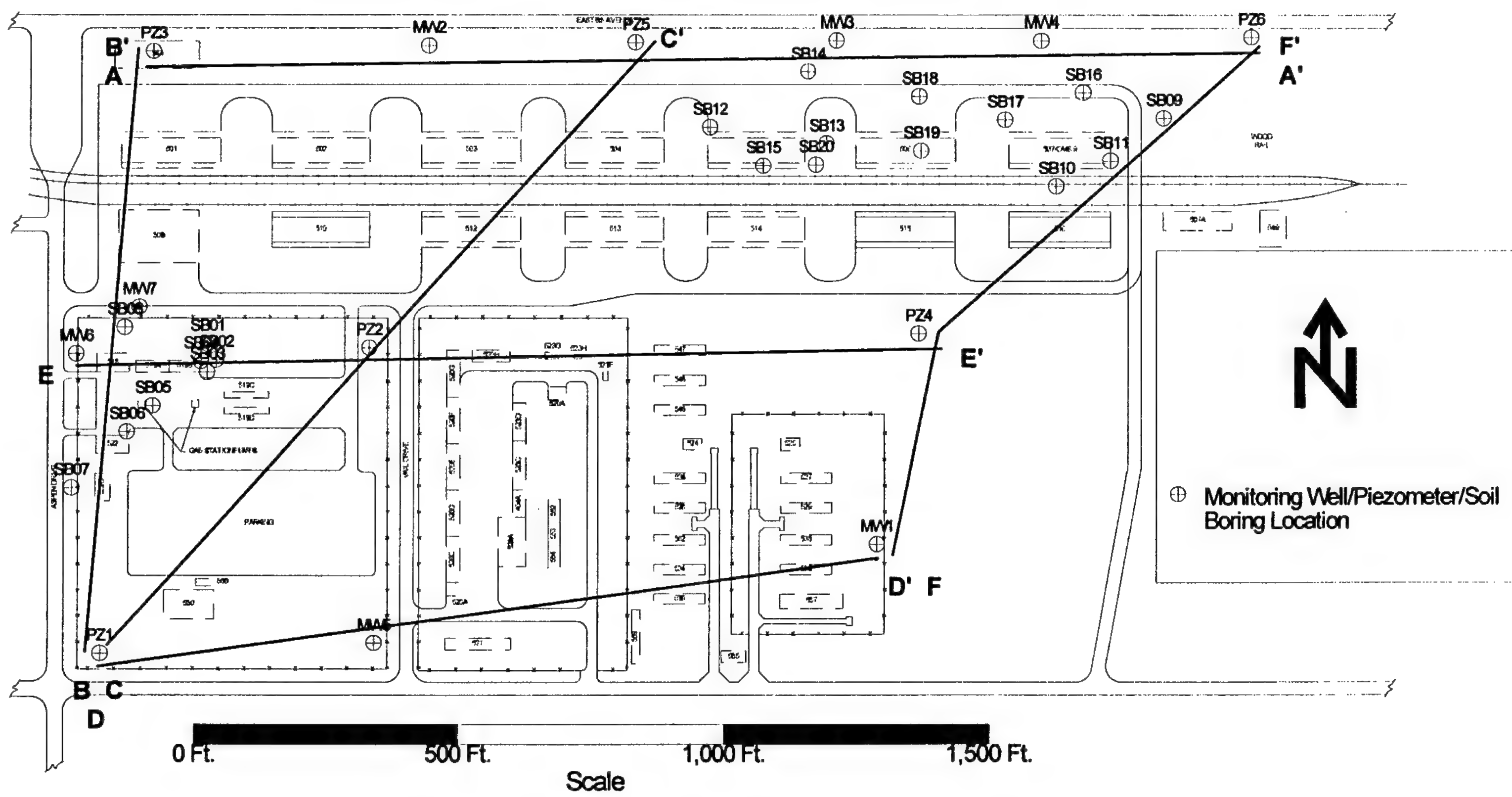
The surficial geology within the FWA consists of eolian and alluvial deposits above the underlying sandstones, siltstones, and shales of the Denver Formation. The eolian deposit consists primarily of contiguous thick sequences of unconsolidated brown clays and silts with traces of very fine sand. The stiffness of the clay and silt increases with depth. These materials are characterized by yellowish and/or red staining, magnesium oxide dendrites, and white mottling. Siltstone of the Denver Formation directly underlies the eolian and alluvial deposits.

The orientations of geological cross sections A-A' through F-F' are presented in Figure 6-1. Figures 6-2 through 6-7 have been prepared to facilitate the analysis of the geologic and hydrogeologic relationship. The cross sections illustrate persistence of the clay and silt layers across the entire FWA. Thin layers of alluvium, consisting of coarser grained deposits, are contiguous over shorter distances and exist only at a single boring location or between several borings. Alluvial sand-sized grains, when present, generally consist of angular quartz, mica, feldspar, and occasionally amphibole minerals.

Infrequent, non-contiguous lenses of alluvial clayey sand, sandy clay, sandy silts, or medium to fine sand range in thickness from a few inches to approximately 3.5 ft. Two contiguous lenses of coarse-grained alluvial sands were observed at the FWA. The largest lens of coarser-grained materials, consisting of a clayey sand grading into a fine to medium sand, occurs between monitoring well FWAMW02 to FWAMW04 at a depth of approximately 15 ft bgs (see Figure 6-2). Evidence of this lens also appears in soil borings FWASB16 and FWASB18 located directly to the south. A lens of clayey sand, silty sand, and sand exists between FWAPZ01, FWASB07, FWASB06, and FWAMW05 at the southwestern portion of the FWA at a depth of approximately 15 to 20 ft bgs (see Figures 6-3 and 6-5).

Bedrock was encountered at two boring locations. A sandy siltstone was encountered at the FWAMW02 boring at a depth of approximately 14 ft bgs. At a depth of 28 ft bgs, a weathered siltstone was encountered at FWASB09. This siltstone represents the erosional surface of the Denver Formation. Borings completed adjacent to these borings and at greater depths did not

Figure 6-1
Orientation of Geologic Cross-Sections



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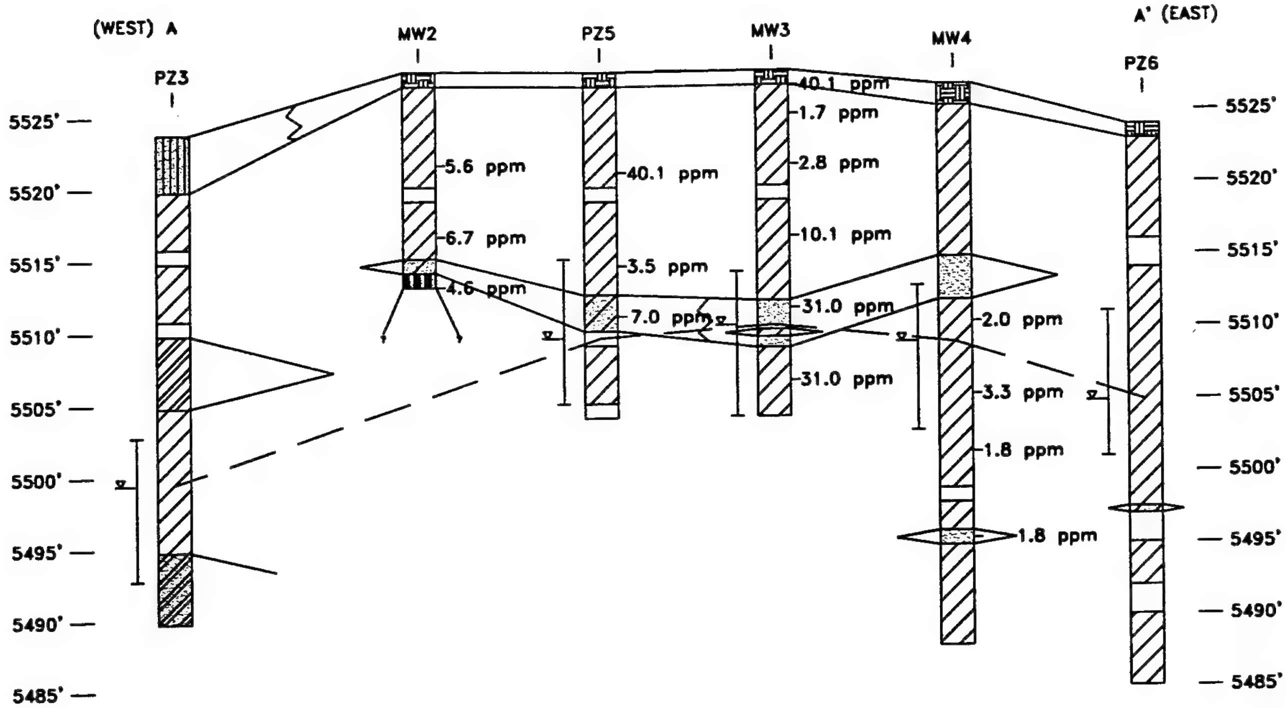

LEGEND

- SCREEN INTERVAL AND GROUNDWATER LEVEL (1/12/97)
- 1.7 PPM–FIELD PID HEAD SPACE (PARTS PER MILLION–AIR)
- NO RECOVERY
- ORGANIC RICH SOIL
- FILL
- SP SAND
- SM SILTY SAND
- SC CLAYEY SAND
- ML SILT
- CL CLAY
- CL/CH SLIGHTLY TO HIGHLY PLASTIC CLAY
- CL/SC SANDY CLAY
- CL/ML CLAYEY SILT
- ML/CL SILTY CLAY
- SM/SC/CL THIN ALT. LAYER OF SILTY SAND, CLAYEY SAND AND CLAY.
- SILTSTONE
- SANDY SILTSTONE

0 100 200 400
HORIZONTAL SCALE: 1 INCH = 400 FEET

0 5 10 20
VERTICAL SCALE: 3/4 INCHES = 10 FEET

FIGURE 6-2
FORMER WAREHOUSE
SITE INVESTIGATION
GEOLOGIC CROSS-SECTION A-A'

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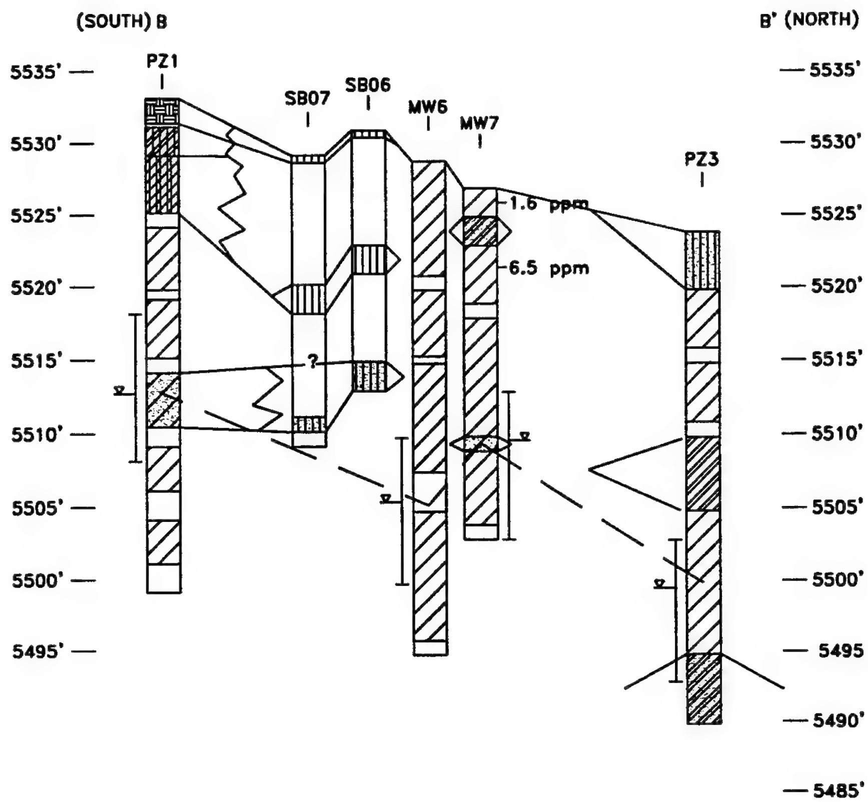

LEGEND

- SCREEN INTERVAL AND GROUNDWATER LEVEL (1/12/97)
- 1.7 PPM–FIELD PID HEAD SPACE (PARTS PER MILLION–AIR)
- NO RECOVERY
- ORGANIC RICH SOIL
- FILL
- SP SAND
- SM SILTY SAND
- SC CLAYEY SAND
- ML SILT
- CL CLAY
- CL/CH SLIGHTLY TO HIGHLY PLASTIC CLAY
- CL/SC SANDY CLAY
- CL/ML CLAYEY SILT
- ML/CL SILTY CLAY
- SM/SC/CL THIN ALT. LAYER OF SILTY SAND, CLAYEY SAND AND CLAY.
- SILTSTONE
- SANDY SILTSTONE

0 100 200 400
HORIZONTAL SCALE: 1 INCH = 400 FEET

0 5 10 20
VERTICAL SCALE: 3/4 INCHES = 10 FEET

FIGURE 6–3
FORMER WAREHOUSE
SITE INVESTIGATION
GEOLOGIC CROSS–SECTION B–B'

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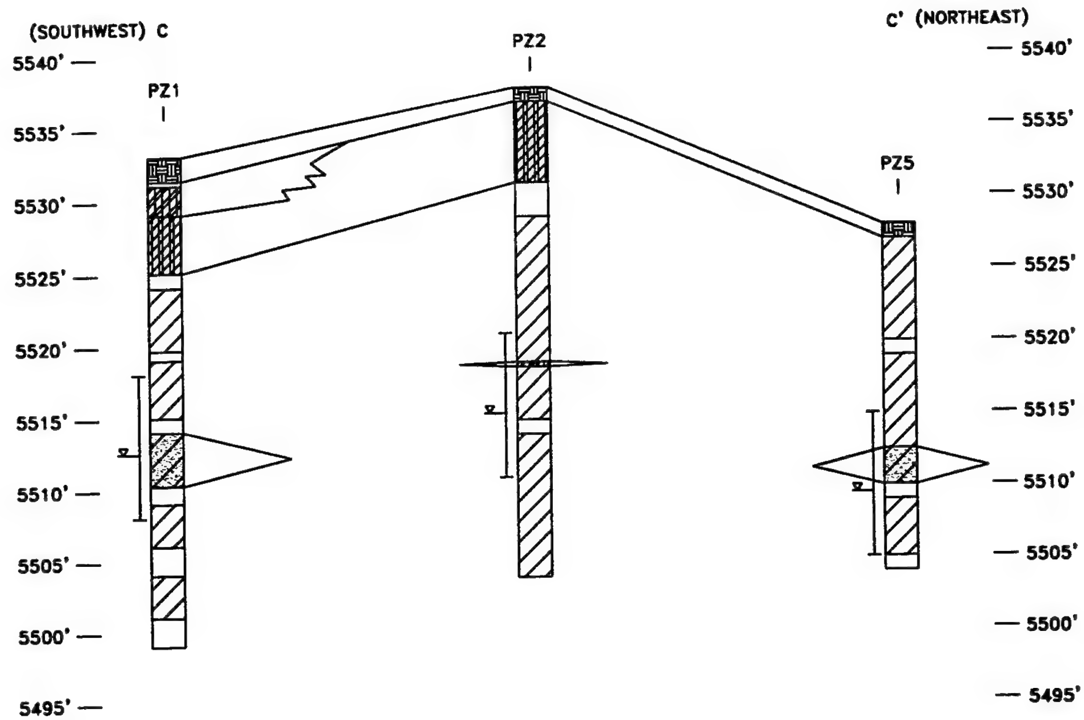

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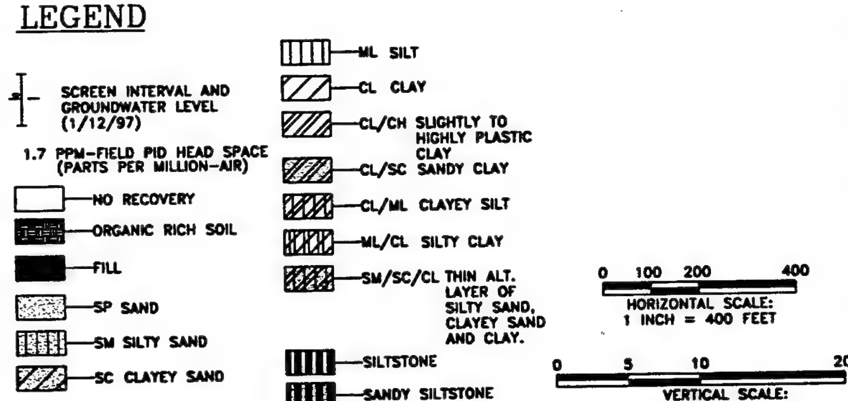

FIGURE 6–4
FORMER WAREHOUSE
SITE INVESTIGATION
GEOLOGIC CROSS–SECTION C–C'

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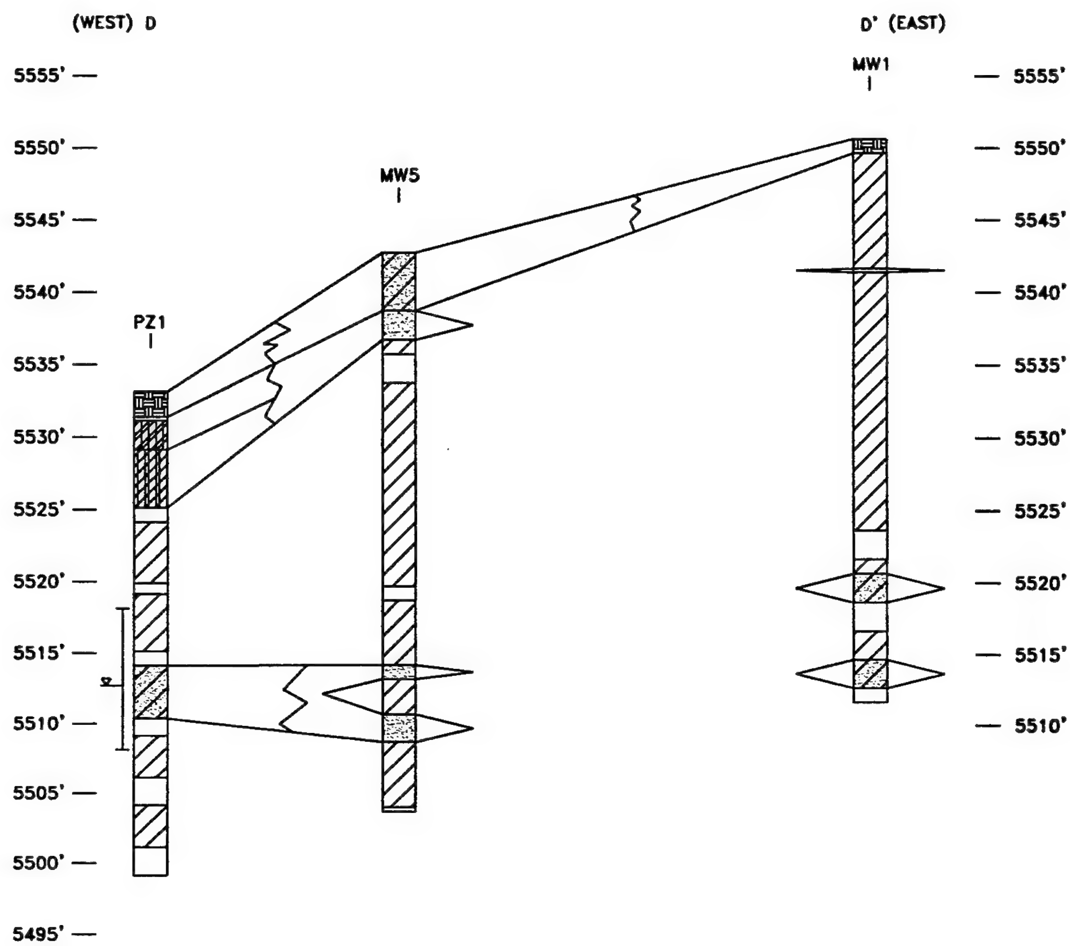

LEGEND

- SCREEN INTERVAL AND GROUNDWATER LEVEL (1/12/97)
- 1.7 PPM–FIELD PID HEAD SPACE (PARTS PER MILLION–AIR)
- NO RECOVERY
- ORGANIC RICH SOIL
- FILL
- SP SAND
- SM SILTY SAND
- SC CLAYEY SAND
- ML SILT
- CL CLAY
- CL/CH SLIGHTLY TO HIGHLY PLASTIC CLAY
- CL/SC SANDY CLAY
- CL/ML CLAYEY SILT
- ML/CL SILTY CLAY
- SM/SC/CL THIN ALT. LAYER OF SILTY SAND, CLAYEY SAND AND CLAY.
- SILTSTONE
- SANDY SILTSTONE

0 100 200 400
HORIZONTAL SCALE:
1 INCH = 400 FEET

0 5 10 20
VERTICAL SCALE:
3/4 INCHES = 10 FEET

FIGURE 6–5
FORMER WAREHOUSE
SITE INVESTIGATION
GEOLOGIC CROSS–SECTION D–D'

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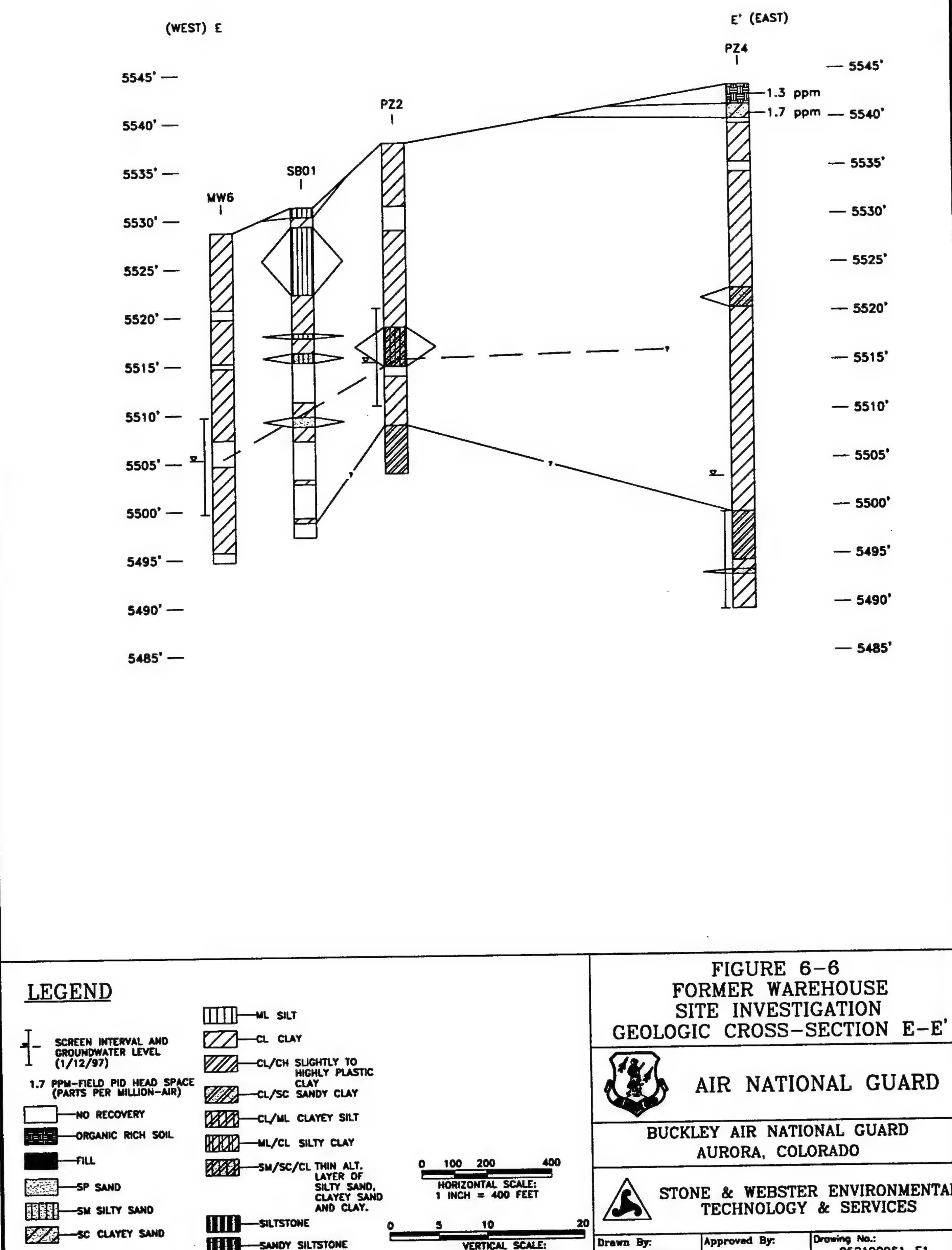

FIGURE 6-6
FORMER WAREHOUSE
SITE INVESTIGATION
GEOLOGIC CROSS-SECTION E-E'

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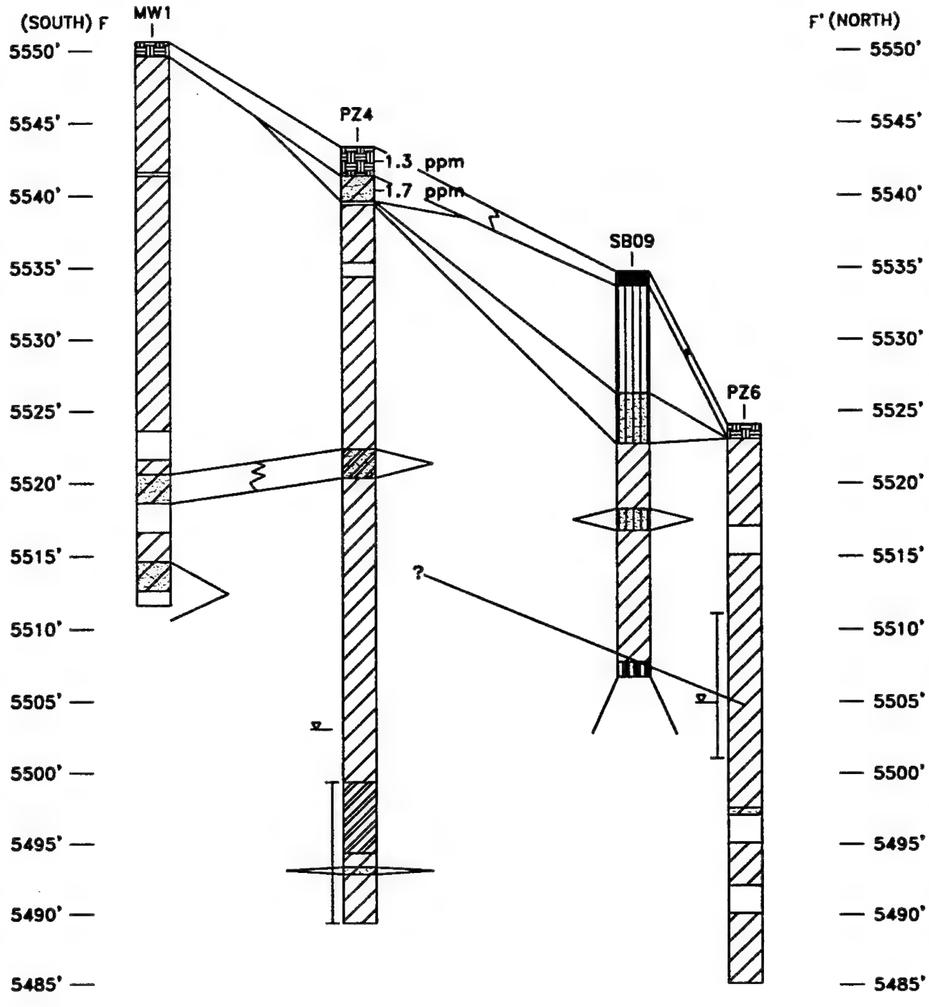

LEGEND

SCREEN INTERVAL AND GROUNDWATER LEVEL (1/12/97)

1.7 PPM–FIELD PID HEAD SPACE (PARTS PER MILLION–AIR)

NO RECOVERY

ORGANIC RICH SOIL

FILL

SP SAND

SM SILTY SAND

SC CLAYEY SAND

ML SILT

CL CLAY

CL/CH SLIGHTLY TO HIGHLY PLASTIC CLAY

CL/SC SANDY CLAY

CL/ML CLAYEY SILT

ML/CL SILTY CLAY

SM/SC/CL THIN ALT. LAYER OF SILTY SAND, CLAYEY SAND AND CLAY.

SILTSTONE

SANDY SILTSTONE

0 100 200 400
HORIZONTAL SCALE: 1 INCH = 400 FEET

0 5 10 20
VERTICAL SCALE: 3/4 INCHES = 10 FEET

FIGURE 6–7
FORMER WAREHOUSE
SITE INVESTIGATION
GEOLOGIC CROSS–SECTION F–F'

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encounter bedrock, indicating that the elevation of the Denver Formation's erosional surface is highly variable. The Denver Formation within the vicinity of the Buckley ANGB consists of variably consolidated, interbedded shale, claystone, siltstone, and sandstones.

Most soils of the FWA are disturbed (i.e., plowed soil and fill material) and not natural within the first 2 ft of the land surface. Much of FWA land surface has been reworked due to former construction and recent demolition of buildings. Asphalt was present at the surface at borings conducted in the vicinity of the Former Warehouses. This asphalt is underlain with a thin layer of gravel and/or sand. Gravel and clayey gravel, sometimes covered with disturbed soil, was present along the location of the former railroad tracks that existed between the two rows of former warehouses. Soils with organic matter generally consist of clays, silts, and sandy silts.

6.1.2 Hydrogeology

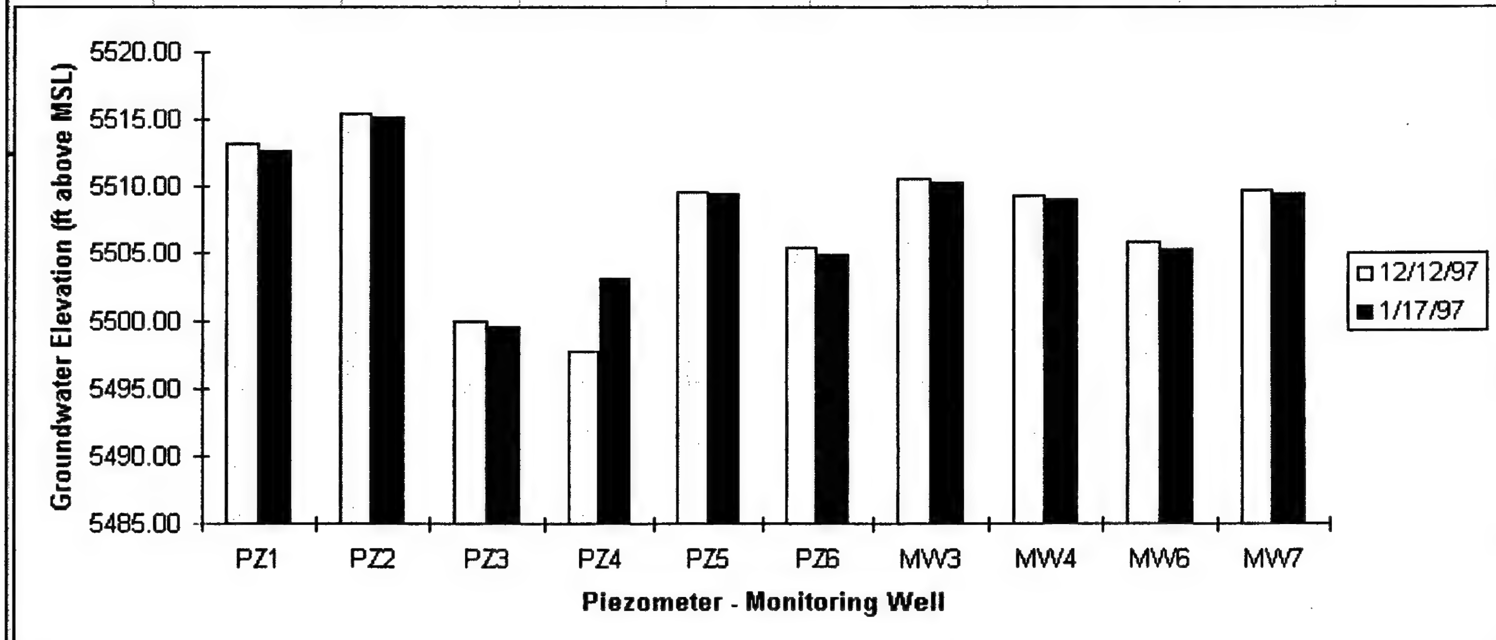
This section summarizes the characteristics of the hydrogeology at the FWA. These characteristics were determined from geologic and hydrogeologic information obtained during the FWA SI. The focus of this investigation was on the surficial aquifer within the eolian deposits, and not the Denver Aquifer.

Limited amounts of groundwater are present within the eolian deposits that comprise the surficial aquifer at the FWA. Groundwater primarily occurs within perched lenses of eolian material within a matrix of hydraulically tight silts and clays. The presence of significant groundwater was absent at some boring locations. The surficial aquifer is locally unconfined to semi-confined within the FWA. Silts and clays act as aquitards, while sands are aquifers. The degree of interconnectiveness among and between these layers primarily determines unconfined and semi-confined conditions. Although confining characteristics of the surficial aquifer were not directly investigated, site hydrogeology and observations of groundwater levels suggest that unconfined to semi-confined aquifer conditions exist.

Groundwater levels from the FWA piezometers and monitoring wells were obtained on December 12, 1996 and January 17, 1997. This information is presented in Table 6-1, along with a graphic representation of the data. Static groundwater levels across the FWA range from 5515.47 to 5497.78 ft above MSL at piezometers FWAPZ02 and FWAPZ04, respectively. Groundwater is approximately 20 to 45 ft bgs across the FWA. Groundwater levels across the site declined slightly between the December 1996 and January 1997 measurements. This decline in groundwater levels is probably the result of a precipitation decrease and resultant infiltration recharge to surficial groundwater. This decrease occurred at all piezometers and monitoring wells except for piezometer FWAPZ04. Piezometer FWAPZ04, screened primarily within clays and silts, exhibited very slow groundwater level recoveries and does not present a reliable representation of the true groundwater levels.

Table 6-1
Monitoring Well and Piezometer Reference and Groundwater Elevations

			December 12, 1996			January 17, 1997		
Well Piezometer number	Top of Casing Elevation (feet above MSL)	Ground Elevation (feet above MSL)	Depth to Water (feet)	Depth from Ground Surface (ft)	Groundwater Elevation (feet above MSL)	Depth to Water (feet)	Depth from Ground Surface (ft)	Groundwater Elevation (feet above MSL)
PZ1	5535.86	5533.12	22.62	19.88	5513.24	23.16	20.42	5512.70
PZ2	5540.66	5537.76	25.19	22.29	5515.47	25.46	22.56	5515.20
PZ3	5526.58	5523.78	26.60	23.80	5499.98	27.12	24.32	5499.46
PZ4	5545.69	5543.39	47.91	45.61	5497.78	42.59	40.29	5503.10
PZ5	5530.90	5527.97	21.27	18.34	5509.63	21.41	18.48	5509.49
PZ6	5526.90	5524.09	21.47	18.66	5505.43	21.95	19.14	5504.95
MW3	5530.80	5528.07	20.24	17.51	5510.56	20.45	17.72	5510.35
MW4	5529.61	5527.01	20.20	17.60	5509.41	20.47	17.87	5509.14
MW6	5531.58	5528.69	25.68	22.79	5505.90	26.24	23.35	5505.34
MW7	5529.52	5526.79	19.71	16.98	5509.81	19.98	17.25	5509.54



Groundwater potentiometric maps depicting groundwater levels and the flow directions of the surficial aquifer are presented in Figures 6-8 through 6-11. Two sets of potentiometric maps are presented for each round of groundwater level measurements. Each set of maps depicts the groundwater potentiometric surface with and without incorporation of the groundwater level measured at piezometer FWAPZ04. Measured groundwater levels within piezometer FWAPZ04 are significantly lower and had a greater variation than groundwater levels measured at all other FWA monitoring wells and piezometers. When used to prepare potentiometric contour maps, the low groundwater levels from piezometer FWAPZ04 greatly influence groundwater flow directions toward the piezometer. This effect results in erroneous or inconsistent groundwater potentiometric mapping that is not consistent with the hydrogeologic model of the FWA. In addition, the distribution of groundwater contaminants in the vicinity of the Former Depot area does not support piezometer FWAPZ04 as a downgradient well. As a result, the potentiometric maps that exclude piezometer FWAPZ04 data provide the most accurate depiction of groundwater levels and flow directions (see Figures 6-8 and 6-10).

Groundwater gradients and flow directions measured on December 12, 1996 and January 17, 1997, are very similar (see Figures 6-8 and 6-10). In general, surficial groundwater flows northerly across the FWA, roughly following surface topography. Groundwater flows toward the northwest on the western portion of the site. Flow becomes more westerly in the southwestern area of the FWA. On the eastern portion, groundwater flow is toward the northeast. A groundwater divide appears to exist across the site extending from monitoring well FWAMW03 southwest to FWAPZ02 and southward. This divide is evident in both the December 1996 and January 1997 groundwater level data.

Groundwater gradients of the surficial aquifer are high along the western side and low along the east and northeast side of the FWA. In December 1996, groundwater gradients on the western side of the FWA range from 0.022 between piezometers FWAPZ02 and FWAPZ03, and 0.017 between piezometer FWAPZ02 and monitoring well FWAMW06. The January 1997 groundwater gradient between piezometer FWAPZ02 and monitoring well FWAMW06 changed very slightly to 0.018, but remained the same between piezometers FWAPZ02 and FWAPZ03. The groundwater gradient, on the eastern side of the FWA, measured between piezometers FWAPZ02 and FWAPZ06, remained the same at 0.006 for December 1996 and January 1997.

The hydraulic conductivity of the surficial aquifer at the FWA was investigated by performing slug tests on all monitoring wells and piezometers. The range of hydraulic conductivity values across the FWA is fairly uniform. Conductivity values have a variation of less than 2 orders of magnitude ranging from 4.93×10^{-6} ft/s (1.50×10^{-4} cm/s) at FWAMW03 to 8.79×10^{-7} ft/s (2.68×10^{-5} cm/s) at FWAPZ01. The hydraulic conductivity geometric mean calculated for the FWA surficial aquifer is 1.17×10^{-6} ft/s (3.57×10^{-5} cm/s). This value is consistent with the reported values for silt, loess, and silty sand deposits (Freeze and Cherry, 1979).

Previous investigations at the Buckley ANGB have reported higher hydraulic conductivity values ranging from 4×10^{-4} ft/s (1.2×10^{-2} cm/s) to 1×10^{-6} ft/s (3.0×10^{-5} cm/s) (SAIC, 1995). However, previous studies were primarily conducted in the alluvial deposits, and not within the

Figure 6-8
FWA Site Investigation
Groundwater Potentiometric Surface - December 12, 1996
Without Piezometer FWAPZ04 Groundwater Level

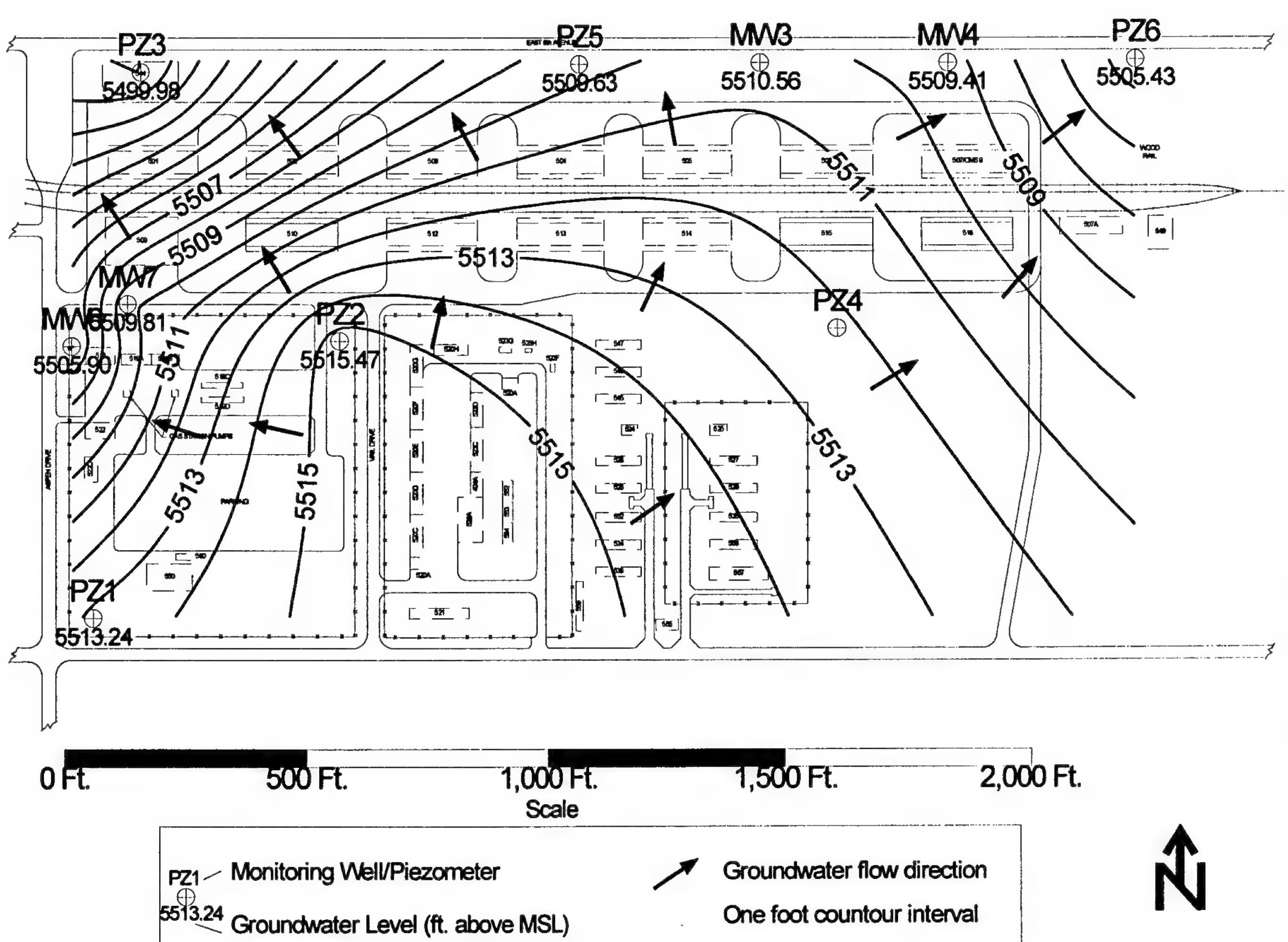


Figure 6-9
FWA Site Investigation
Groundwater Potentiometric Surface - December 12, 1996
With Piezometer FWAPZ04

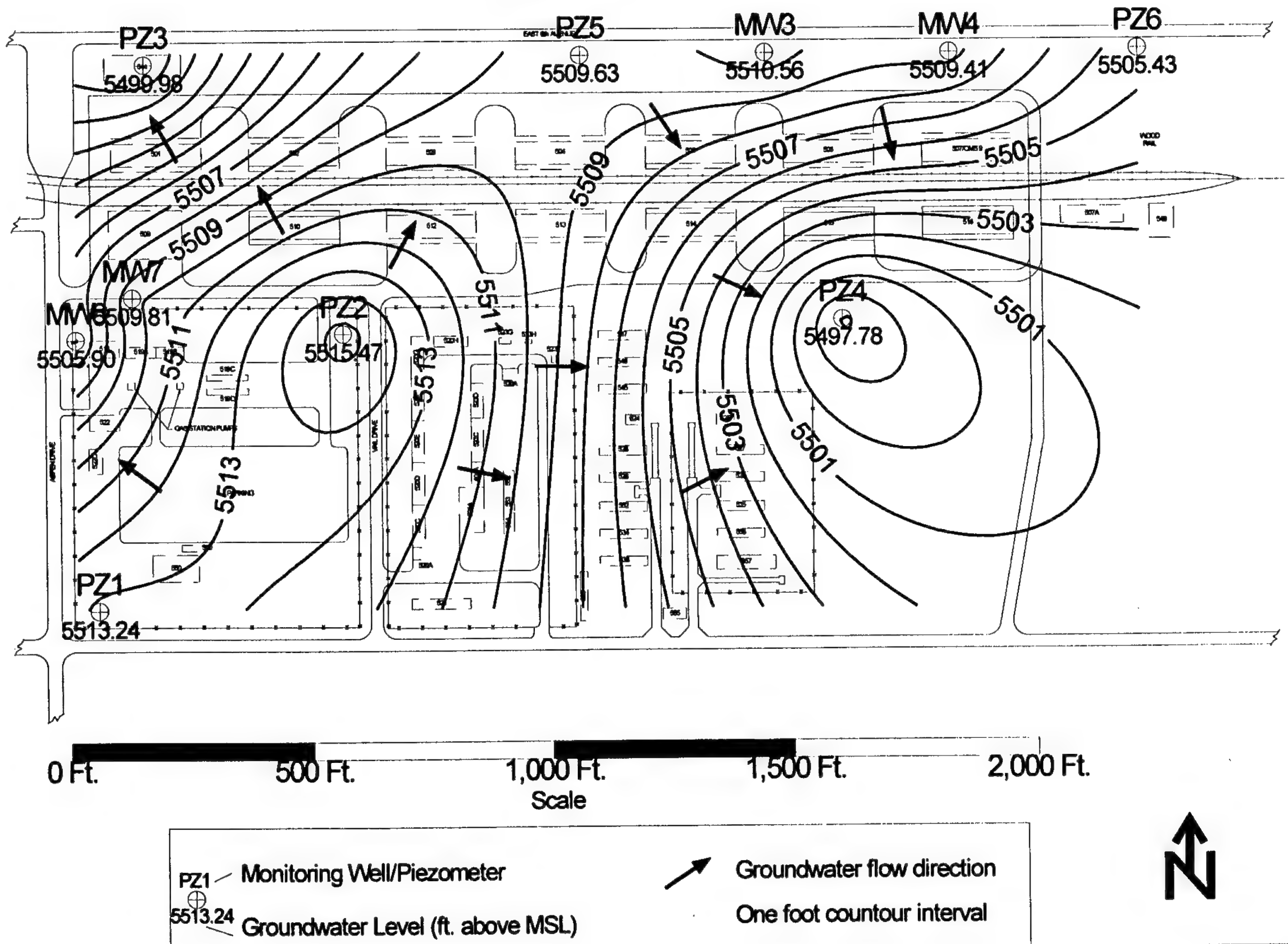


Figure 6-10
FWA Site Investigation
Groundwater Potentiometric Surface - January 17, 1997
Without Piezometer FWAPZ04 Groundwater Level

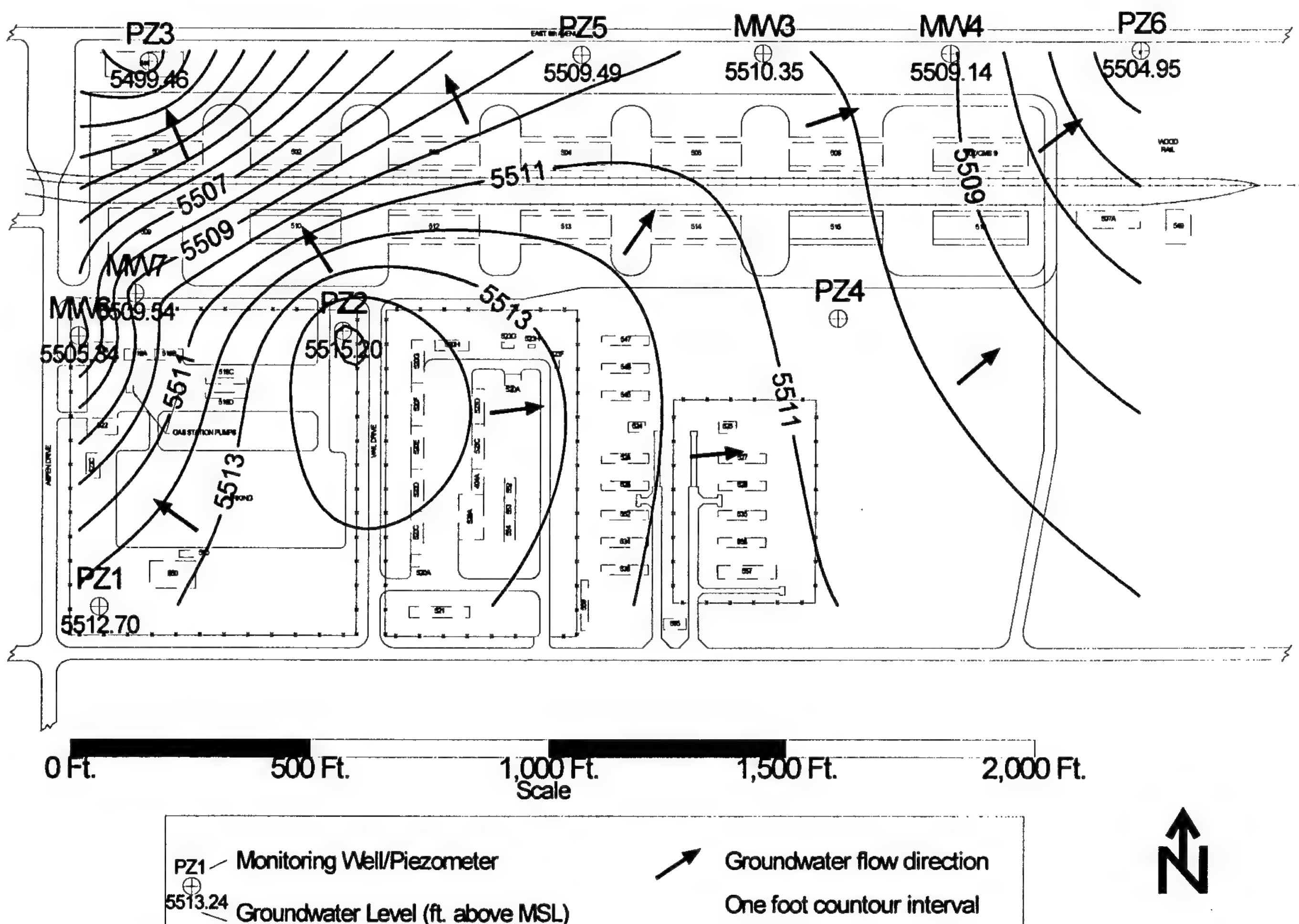
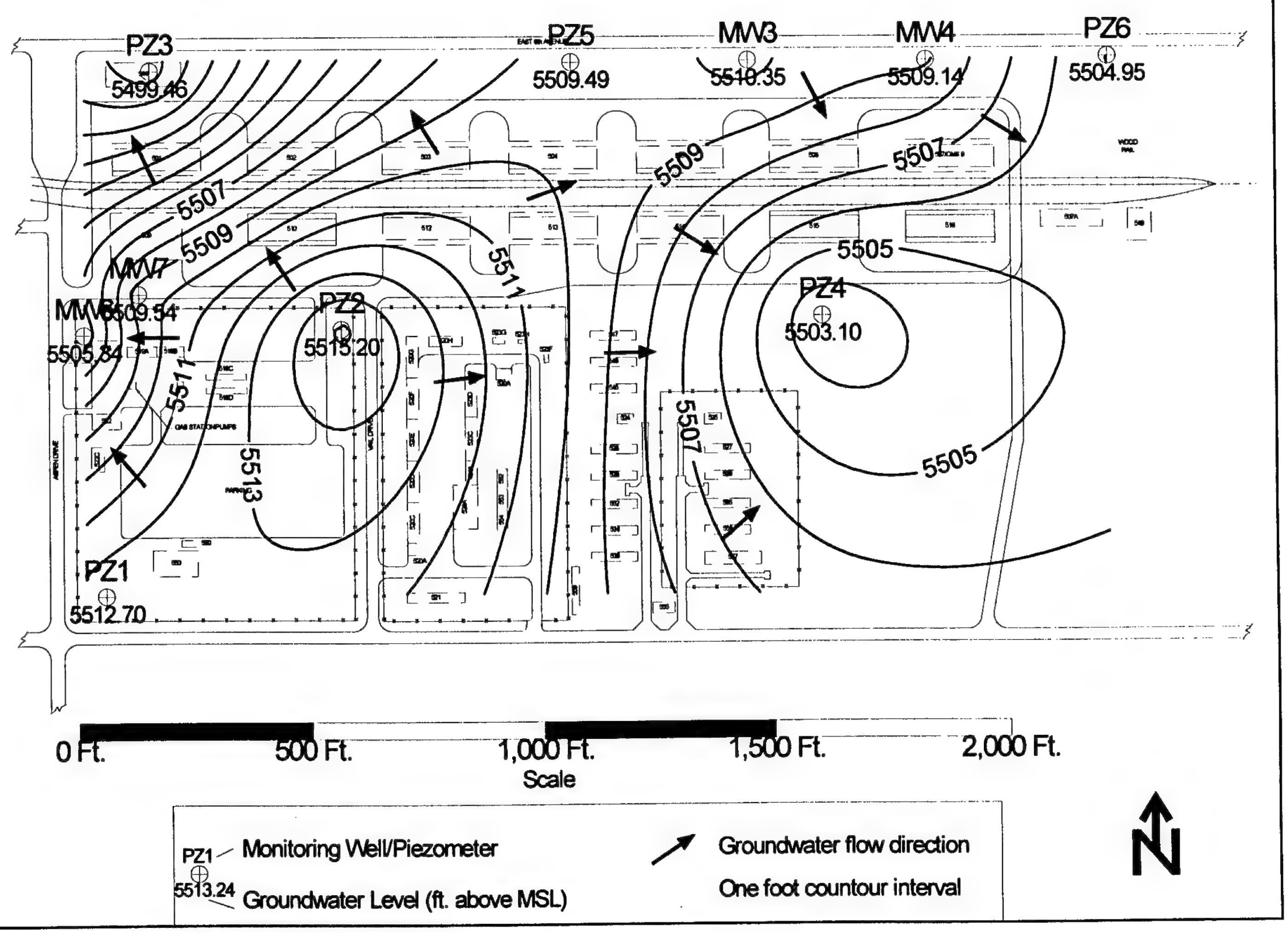


Figure 6-11
FWA Site Investigation
Groundwater Potentiometric Surface - January 17, 1997
With Piezometer FWAPZ04 Groundwater Level



loess and eolian sand deposits of the FWA. Alluvial deposits are coarser grained than the loess and eolian deposits, accounting for the higher values for hydraulic conductivity in the alluvium.

An area of relatively high conductivity is evident across the FWA from the area of monitoring wells FWAMW06 and FWAMW07 and piezometer FWAPZ02 to the north eastern side of the site in the vicinity of monitoring well FWAMW03. Areas of relatively low hydraulic conductivity occur in the northwest, southwest, and central eastern portions of the FWA as determined by piezometers FWAPZ03, FWAPZ01, and FWAPZ04. Appendix G presents the results of hydraulic conductivity testing and a detailed discussion of data calculations and interpretations.

The vertical movement of groundwater at the FWA was beyond the scope of the FWA SI and was not investigated. However, groundwater movement in the surficial aquifer at other locations at Buckley ANGB is reported to be downward toward the Denver aquifer (SAIC, 1995). Ratios of vertical to horizontal hydraulic conductivity commonly range from 1:2 to 1:10 (Walton, 1984). Therefore, vertical hydraulic conductivity may vary between 5.85×10^{-6} ft/s (1.79×10^{-4} cm/s) to 1.17×10^{-7} ft/s (3.57×10^{-6} cm/s).

The horizontal velocity of surficial groundwater at the FWA was assessed using calculated hydraulic conductivity, gradient, and effective soil porosity values. Effective porosity (n_e) values of 0.3 and 0.2 were used to represent an average for the clayey, silty, and sandy soil encountered at the site. The highest and lowest calculated hydraulic gradients (i) and hydraulic conductivity (K) geometric mean were used in determining groundwater horizontal velocity. Groundwater velocity is calculated as:

$$V = \frac{Ki}{n_e}$$

Based on the hydraulic conductivity geometric mean, the velocity of groundwater varies from 4.06 ft/yr to 0.73 ft/yr, depending on gradient and porosity. Table 6-2 summarizes the range of possible groundwater horizontal velocities dependent upon gradient and porosity at the FWA.

Table 6-2
Range Of Groundwater Flow Velocities

Hydraulic Conductivity (K)	Gradient (i)	Porosity (n_e)	Velocity
1.17×10^{-6} ft/s (3.57×10^{-5} cm/s) (geometric mean)	0.022	0.30	2.71 ft/yr
		0.20	4.06 ft/yr
	0.006	0.30	0.73 ft/yr
		0.20	1.10 ft/yr

6.2 GEOPHYSICAL SURVEY RESULTS

A geophysical survey was conducted at the Former AF Motor Pool area and the north side of Former Warehouse 505 in the Former Depot area. Magnetic and electromagnetic (EM) surveys were conducted. Results of these surveys are discussed in detail in Appendix D and are summarized here.

6.2.1 Former AF Motor Pool Geophysical Survey Results

Numerous magnetic anomalies were reported within the Former AF Motor Pool area. Total magnetic field contour maps presented in Appendix D, Figures 4 and 5, indicate the north-central portion of the site is magnetically cluttered by cultural features. These cultural features include a vent pipe, intake pipes, and concrete vault boxes. Interpretation of the data indicates the presence of USTs or other large buried metallic objects in the northeastern portion of the Former AF Motor Pool area.

The EM data are similar to the magnetic data and are presented in Appendix D, Figures 6 and 7. The EM data indicates the presence of many conductive objects with "bullseye" type contour highs, particularly in the north-central portion of the grid, which correspond with mapped cultural features. The EM data confirm the presence of buried conductive objects within the area of the probable USTs identified by the magnetic data. The high EM conductivity present in this area is larger than would be anticipated due to the presence of cultural features.

Several unexplained EM anomalies are located in the southern portion of the site, extending southwest and east of a manhole cover. These anomalies are interpreted to be relatively shallow conductive objects (e.g., demolition debris and underground utilities) because their signatures are not observed in the magnetic data.

6.2.2 Former Warehouse 505 Geophysical Survey Results

The total magnetic field contour maps, shown in Appendix D, Figures 8 and 9, indicate the Former Warehouse 505 site is magnetically quiet, except for cultural features. All of the cultural features encountered in the field are shown on Appendix D, Figure 9, where they were clearly mapped with the magnetic data.

A north-south trending 4-inch diameter pipe, exposed at the ground surface for about 4 to 5 ft, caused a large dipolar feature in the magnetic data. This dipolar feature is typical for a ferrous pipe of this dimension and orientation.

The EM survey data are similar to the magnetic data where identified cultural features account for EM anomalies. However, two narrow strips of relatively high conductivity are present as shown on Appendix D, Figures 10 and 11. The northern anomaly is interpreted to relate to the change in soil conditions from a uniformly low conductivity (resistive) dry road-base material to a fairly conductive moist soil (with higher fines content) that is north beyond the road. The east-west linear conductivity feature is interpreted as a shallow buried conductive object, possibly an abandoned

utility line. The short north-south linear feature located along the northwest corner of Former Warehouse 505 appears to be tied to the east-west EM feature, suggesting that it may have been a utility conduit that served the warehouse.

The main objective of conducting the geophysical survey at Former Warehouse 505 was to locate an alleged dry well, possibly used for waste disposal. Neither the magnetic nor EM survey data indicated the presence of a buried vertical well casing/pipe that may have served as a drain to the dry well. The presence of a dry well was not detected in the magnetic or EM survey data.

6.3 SOIL GAS SURVEY RESULTS

A soil gas survey was conducted as part of the FWA SI. A total of 200 soil gas samples were collected and analyzed for VOCs, O_2, and CO_2 from the Former AF Motor Pool and Former Warehouses 505, 506, and 507 of the Former Depot area. Results of the soil gas survey were used to determine direct push soil sampling and monitoring well locations. Figure 6-12 presents the general locations of all soil gas samples collected at the Former AF Motor Pool and Depot areas.

6.3.1 Former AF Motor Pool Area Soil Gas Survey Results

A total of 62 soil gas samples were obtained and analyzed within the area of the Former AF Motor Pool area. Soil gas samples SG1 through 36, 89 through 96, 135 through 147, 175, 176, and 190 through 192 were obtained and analyzed for VOCs, O_2, and CO_2. Sample SG192 was obtained from within the west UST to test for the presence of VOCs. A summary of the soil gas survey results for the Former AF Motor Pool is presented in Table 6-3. Figure 6-13 presents all soil gas sampling locations at the Former AF Motor Pool area.

A total of 15 VOCs were reported within the soils at the Former AF Motor Pool area. These organic compounds included acetone, xylenes, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2-dichlorobenzene, benzene, ethylbenzene, toluene, chlorobenzene, 1,1,2-trichloroethane, PCE, TCE, 2-hexanone, and 4-methyl-2-pentanone. Acetone was the most prevalent of these compounds at a maximum concentration of 95 µg/l air at soil gas sampling location FWASG028. PCE was the second most prevalent compound with the highest maximum concentration of all reported organic compounds at 160 µg/l air at soil gas sampling location FWASG146. The xylenes and dichlorobenzenes generally occurred together at low concentrations. Sample data for benzene, toluene, chlorobenzene, 1,1,2-trichloroethane, TCE, and 2-hexanone were infrequently reported at very low concentrations.

The distribution of acetone, PCE, and total VOCs reported within soil gas samples at the Former AF Motor Pool area is presented in Figures 6-14, 6-15, and 6-16, respectively. Overall, low soil gas concentrations are prevalent across the study area, suggesting low concentrations of VOCs within the shallow subsurface soils and/or groundwater. Isolated areas with relatively high total soil gas VOC levels include the southwestern and northwestern boundary along Aspen Drive, an area south of the concrete pad and west of the USTs, and the center of the study area. The compound PCE was reported at 15 sampling locations along the western boundary and the southeastern portion of the study area. Soil gas samples taken within the vicinity of the USTs were reported to contain low amounts of xylenes, dichlorobenzene, ethylbenzene, and acetone. The compound PCE was not reported within 100 ft of the USTs, suggesting that the USTs may not be a PCE source. In addition, the results of the sample (analyzed as a soil gas sample) obtained from within the western UST did not report VOCs, suggesting that the tank is empty.

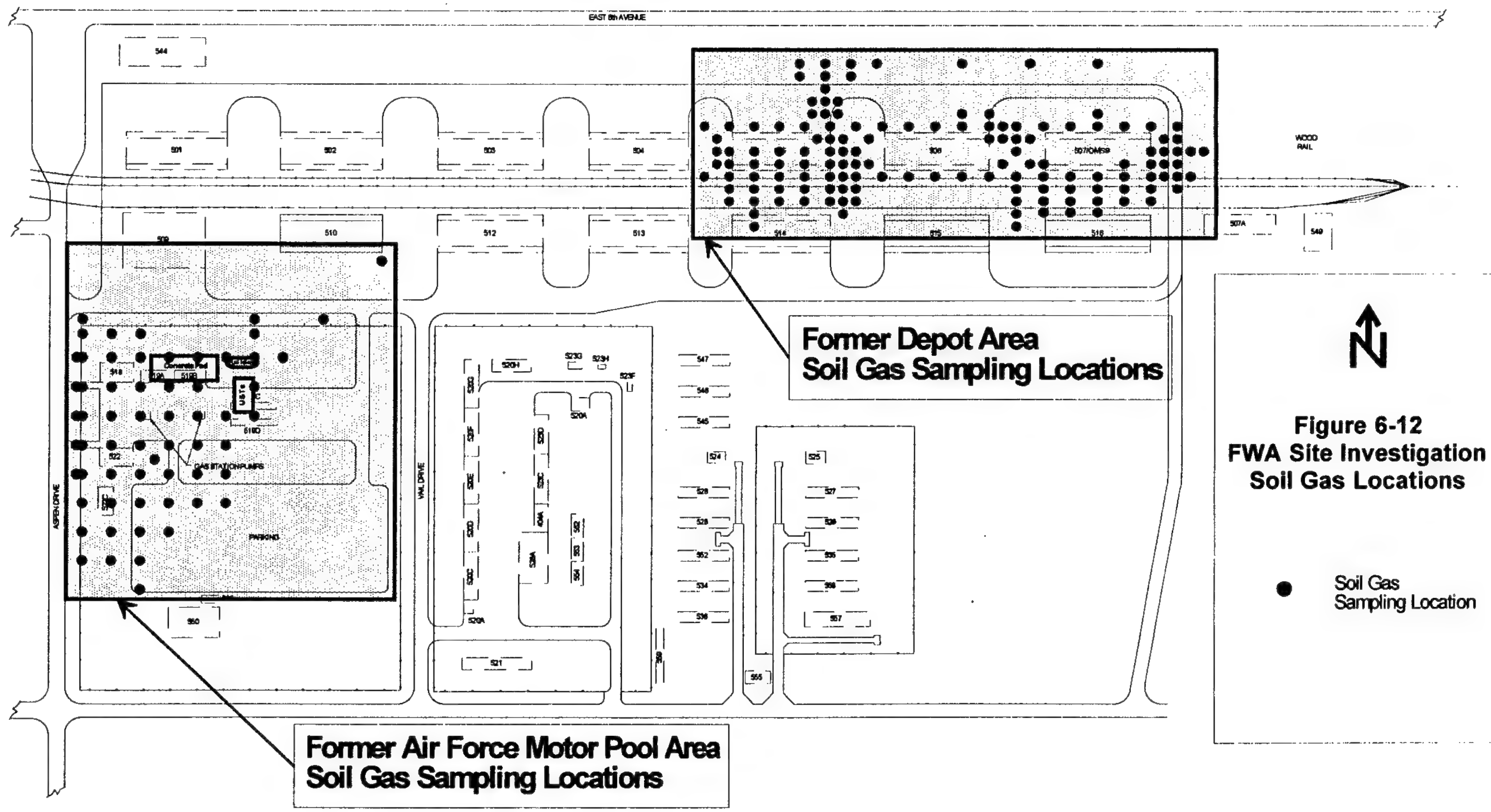


**Figure 6-12
FWA Site Investigation
Soil Gas Locations**

Table 6-3
Soil Gas Survey Results - FWA - Former Air Force Motor Pool Area

Sample	O2 (%)	CO2 (%)	Acetone µg/l (vol)	m+p Xylenes µg/l (vol)	o-xylene µg/l (vol)	1,3-Dichloro-benzene µg/l (vol)	1,4-Dichloro-benzene µg/l (vol)	1,2-Dichloro-benzene µg/l (vol)	Benzene µg/l (vol)	Ethyl-benzene µg/l (vol)	Toluene µg/l (vol)	Chloro-benzene µg/l (vol)	1,1,2-Trichloro-ethane µg/l(vol)	Tetra-chloro-ethene µg/l (vol)	Trichloro-ethene µg/l (vol)	2-Hexanone µg/l (vol)	4-Methyl-2-pentanone µg/l (vol)	Total VOCs µg/l (vol)
SG001	NC	ND																0.0
SG002	NC	ND	15.0															15.0
SG003	NC	ND																0.0
SG004	NC	ND																0.0
SG005	NC	1.1																0.0
SG006	NC	1.3	25.0															25.0
SG007	NC	ND	24.0	2.0		1.0	1.0	1.0										29.0
SG008	NC	1.9	31.0															31.0
SG009	NC	2.9	23.0															23.0
SG010	NC	ND	23.0						13.0									36.0
SG011	NC	1.5	53.0							6.0								59.0
SG012	NC	2.9																0.0
SG013	NC	4.5																0.0
SG014	NC	ND	68.0	5.0		2.0	2.0	1.0		4.0								82.0
SG015	NC	7.3	12.0															12.0
SG016	NC	ND	45.0															45.0
SG017	NC	ND	18.0															18.0
SG018	NC	ND																0.0
SG019	NC	ND	19.0	3.0	1.0	2.0	2.0	2.0										29.0
SG020	NC	2.0		4.0	2.0	3.0	3.0	2.0		2.0	1.0	1.0						18.0
SG021	NC	1.7																0.0
SG022	NC	5.8	10.0						5.0									15.0
SG023	NC	2.6	11.0	4.0						26.0			3.0				31.0	75.0
SG024	NC	1.5	15.0							2.2								17.2
SG025	NC	ND								2.0								2.0
SG026	NC	1.0		5.0	1.0	2.0	3.0	2.0		2.0								15.0
SG027	NC	4.3	28.0	2.0		2.0	2.0	1.0										35.0
SG028	NC	3.0	95.0															95.0
SG029	NC	1.4	39.0															39.0
SG030	NC	ND	27.0															27.0
SG031	NC	3.5	19.0															19.0
SG032	NC	3.2																0.0
SG033	NC	5.0	18.0	3.0	1.0	3.0	3.0	2.0				1.0						31.0
SG034	NC	8.6	10.0	2.0														12.0
SG035	NC	3.5	10.0															10.0

Table 6-3 (continued)
Soil Gas Survey Results - FWA - Former Air Force Motor Pool Area

Sample	O2 (%)	CO2 (%)	Acetone µg/l (vol)	m+p Xylenes µg/l (vol)	o-xylene µg/l (vol)	1,3-Dichloro-benzene µg/l (vol)	1,4-Dichloro-benzene µg/l (vol)	1,2-Dichloro-benzene µg/l (vol)	Benzene µg/l (vol)	Ethyl-benzene µg/l (vol)	Toluene µg/l (vol)	Chloro-benzene µg/l (vol)	1,1,2-Trichloro-ethane µg/l(vol)	Tetra-chloro-ethene µg/l (vol)	Trichloro-ethene µg/l (vol)	2-Hexanone µg/l (vol)	4-Methyl-2-pentanone µg/l (vol)	Total VOCs µg/l (vol)
SG036	NC	3.3	31.0						1.0									32.0
SG089	22.0	ND												35.0				35.0
SG090	22.0	ND	26.0															26.0
SG091	21.0	ND																0.0
SG092	22.0	ND								4.6								4.6
SG093	22.0	1.7																0.0
SG094	22.0	ND												1.8				1.8
SG095	14.0	1.9																0.0
SG096	15.0	3.1																0.0
SG135	18.0	ND												28.0				28.0
SG136	21.0	ND												15.0		4.4		19.4
SG137	14.0	3.3												7.0				7.0
SG138	17.0	2.4												9.2				9.2
SG139	19.0	ND	51.0											31.0				82.0
SG140	22.0	ND												1.0				1.0
SG141	21.0	ND												3.0				3.0
SG142	21.0	ND												4.0				4.0
SG143	22.0	ND												1.6				1.6
SG144	20.0	ND												3.9				3.9
SG145	15.0	4.2	85.0											13.0				98.0
SG146	17.0	1.1	37.0											160.0	4.0			201.0
SG147	22.0	ND	43.0															43.0
SG175	21.0	ND												2.0				2.0
SG176	20.0	1.2																0.0
SG190	21.0	ND																0.0
SG191	20.0	ND																0.0
SG192	19.0	ND	24.0															24.0

Note:

All organic concentrations in µg/l (vol).
Blank space implies compound not reported.
NC-not calculated.
ND-not reported.

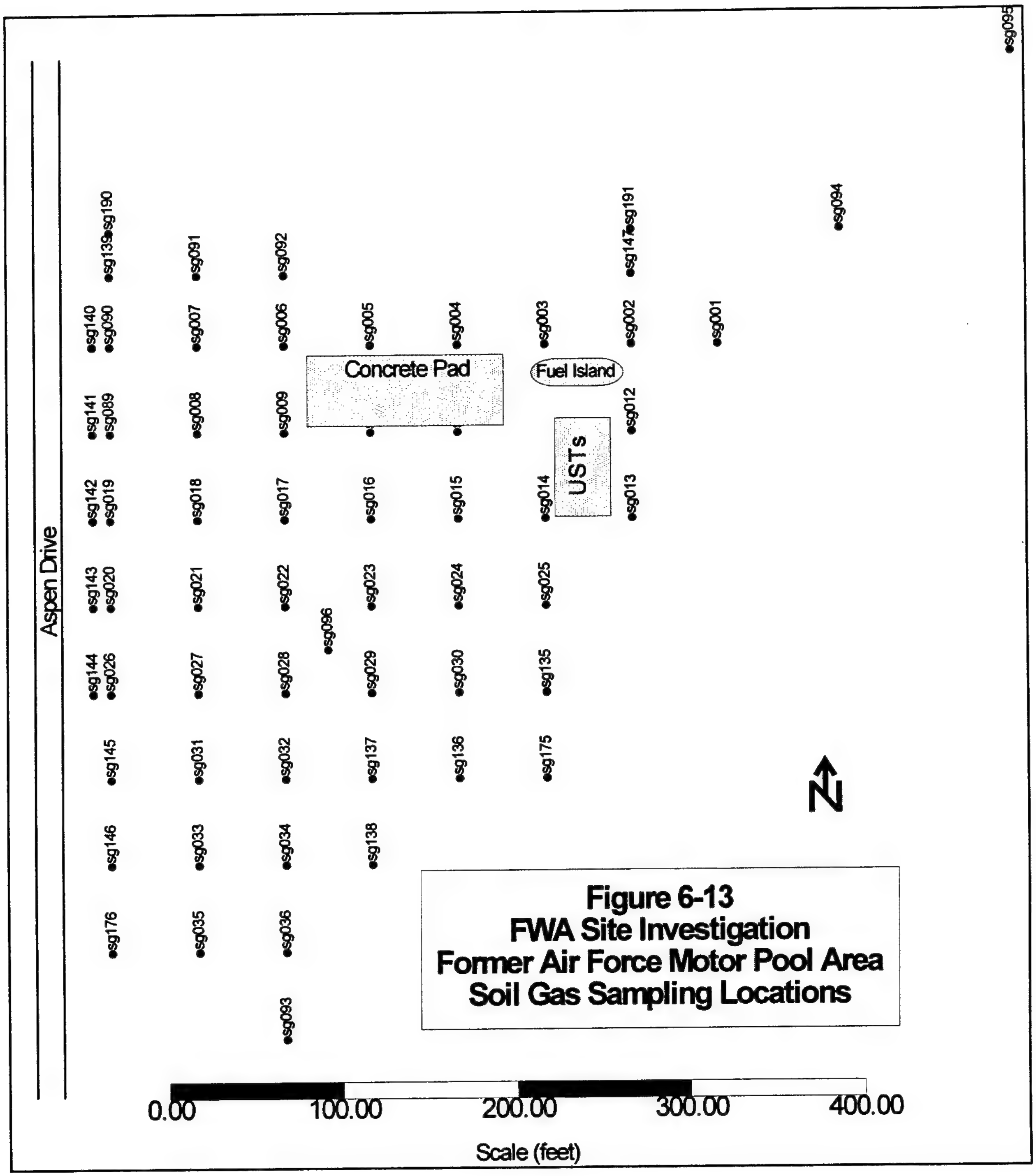


Figure 6-13
FWA Site Investigation
Former Air Force Motor Pool Area
Soil Gas Sampling Locations

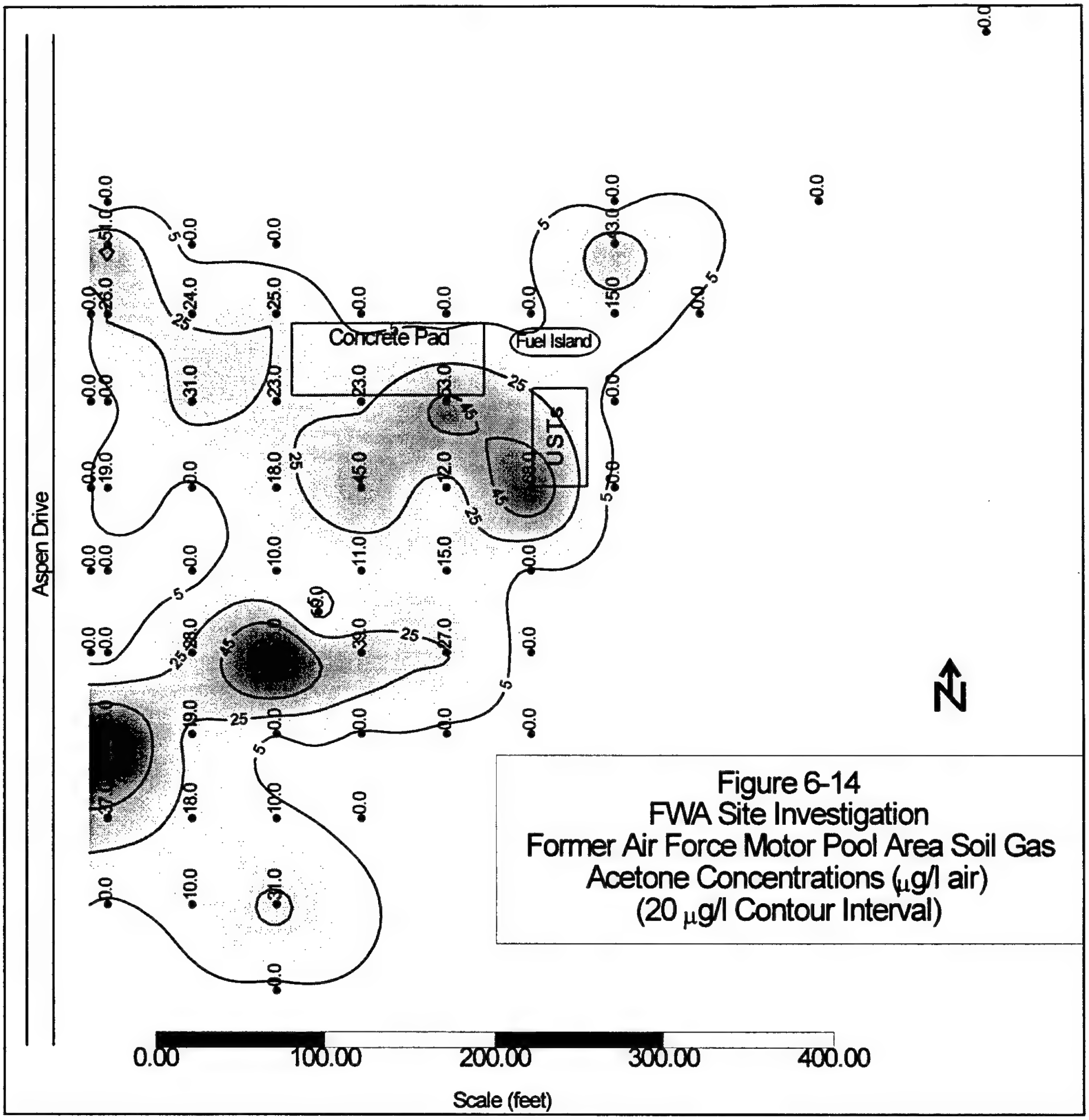


Figure 6-14
FWA Site Investigation
Former Air Force Motor Pool Area Soil Gas
Acetone Concentrations (μg/l air)
(20 μg/l Contour Interval)

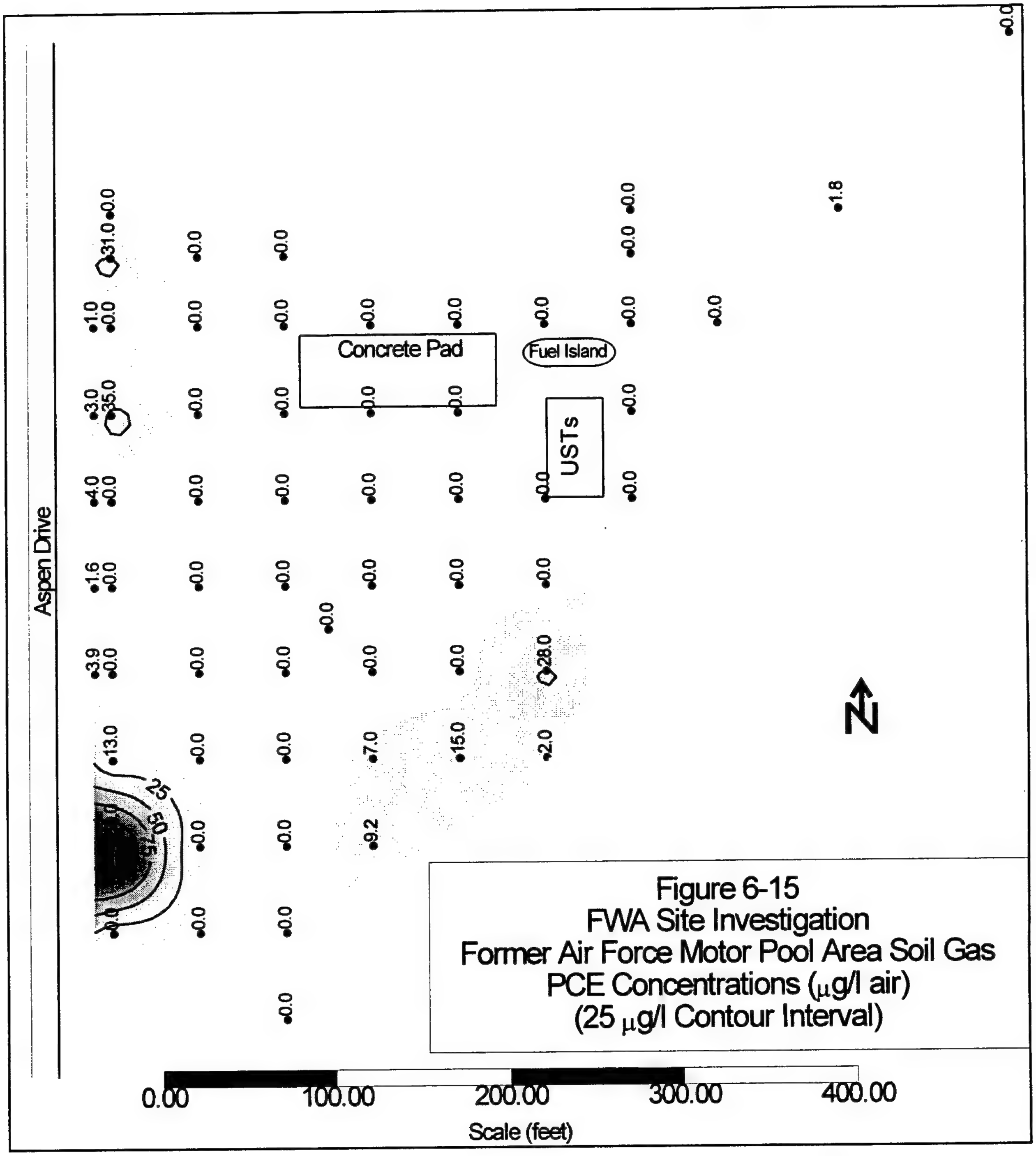


Figure 6-15
FWA Site Investigation
Former Air Force Motor Pool Area Soil Gas
PCE Concentrations (µg/l air)
(25 µg/l Contour Interval)

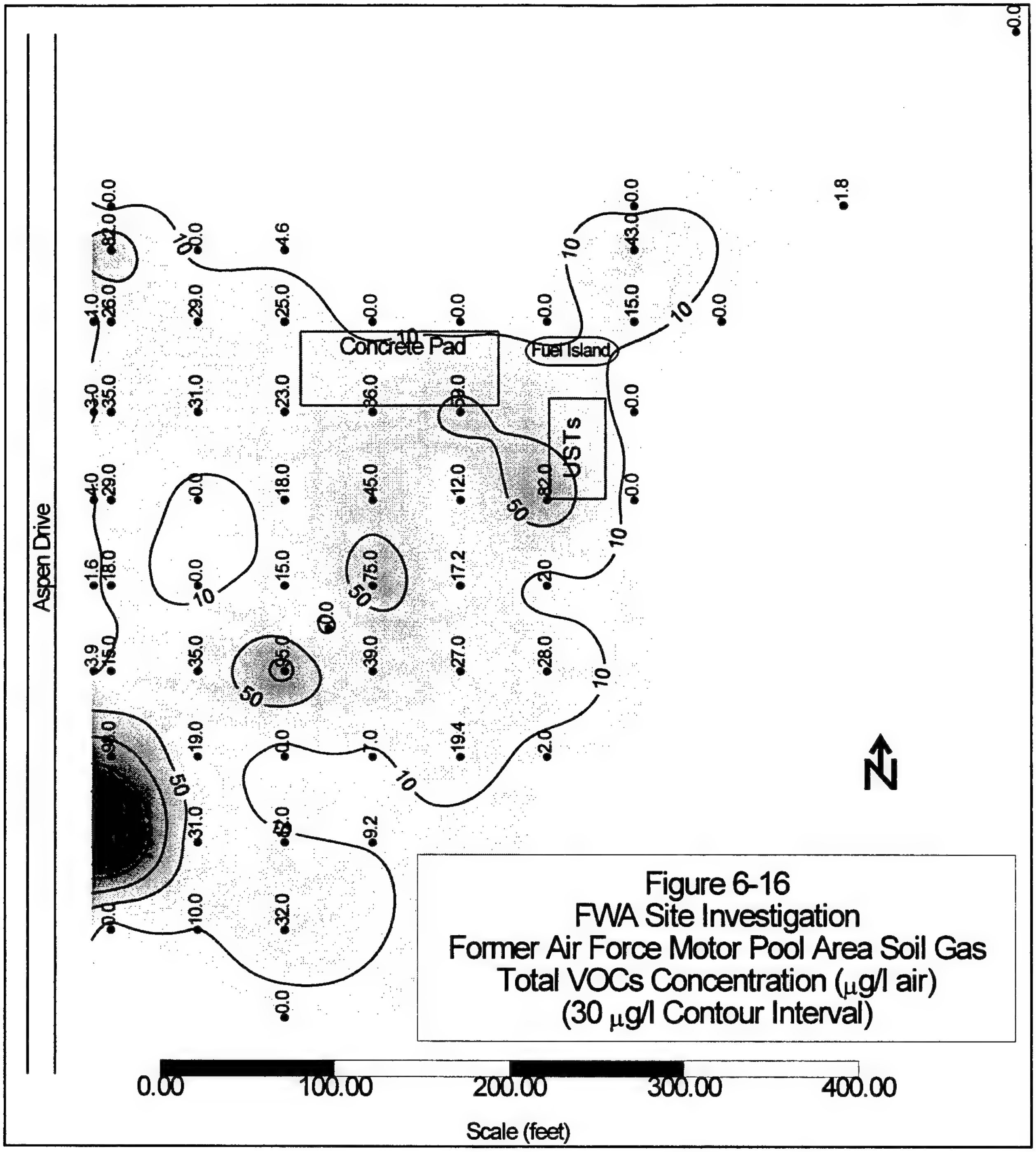


Figure 6-16
FWA Site Investigation
Former Air Force Motor Pool Area Soil Gas
Total VOCs Concentration (μg/l air)
(30 μg/l Contour Interval)

6.3.2 Former Depot Area - Warehouses 505, 506, and 507 Soil Gas Survey Results

A total of 138 soil gas samples were obtained from around the perimeter and within the former foundations of Warehouses 505, 506, and 507 of the Former Depot area. Soil gas samples SG37 through 88, 97 through 134, 148 through 174, 177 through 189, and 193 through 200 were obtained and analyzed for VOCs, O_2, and CO_2. A summary of the soil gas survey results is presented in Table 6-4. Figure 6-17 presents all soil gas sampling locations at the Former Depot area.

A total of eight VOCs were reported within the Former Depot soils in the vicinity of Former Warehouses 505, 506, and 507. These organic compounds included acetone, ethylbenzene, PCE, TCE, xylenes (i.e., m+p-xylenes, o-xylene), benzene, and cis-1,2-dichloroethene. All these compounds were also reported at the Former AF Motor Pool area, except for cis-1,2-dichloroethene. Compounds reported at the Former AF Motor Pool area, but not reported at the Former Depot area, include 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2-dichlorobenzene, toluene, chlorobenzene, 1,1,2-trichloroethane, 2-hexanone, and 4-methyl-2-pentanone.

Acetone and PCE are the most prevalent VOCs reported. PCE occurs most consistently and with the highest concentration. The maximum concentration of acetone is 120 μg/l air at soil gas sampling locations FWASG117 and GWASG118. A maximum concentration of 2,100 μg/l air PCE was reported at soil gas location FWASG111. The compound TCE, a degradation product of PCE, occurs less frequently at a maximum concentration of 86 μg/l air and is always associated with the occurrence of PCE. Ethylbenzene, xylenes, benzene, and cis-1,2-dichloroethene were reported at low concentrations and generally occur with the other reported VOCs.

The occurrence of soil gas VOCs is widespread in the vicinity of Former Warehouses 505, 506, and 507. Figures 6-18, 6-19, and 6-20 present total VOCs, acetone, and PCE soil gas concentrations within this study area. Areas of elevated soil gas concentrations are consistent between these mapped soil gas parameters.

Several areas of elevated soil gas are evident at the Former Depot area. These areas include: (1) the east side of Former Warehouse 507; (2) the area south of Former Warehouse 507 and north of Warehouse 516; (3) the area between Former Warehouses 506 and 507; (4) the east and southeast sides of Former Warehouse 505; (5) the area north of Former Warehouse 505 and East 6th Avenue; and (6) along East 6th Avenue north of Former Warehouse 507. The highest concentration of soil gas VOCs reported, including PCE, occur on the east and southeast sides of Former Warehouse 505. Lower concentrations of PCE were found north of Former Warehouse 505 and between Former Warehouse 507 and Warehouse 516.

Table 6-4
Soil Gas Results - FWA - Former Depot Area - Warehouse Buildings 505, 506, and 507/OMS

Sample	O_2(%)	CO_2(%)	Acetone	Ethyl-benzene	Tetra-chloro-ethene	Trichloro-ethene	m+p-Xylenes	o-Xylene	Benzene	cis-1,2-Dichloro-ethene	Total VOCs
SG037	23.0	3.3	46.0								46.0
SG038	NC	ND	35.0	6.0							41.0
SG039	NC	3.1	90.0	2.0							92.0
SG040	NC	3.0	47.0								47.0
SG041	NC	1.3	15.0								15.0
SG042	17.0	1.5			34.0						34.0
SG043	16.0	3.1			2.0						2.0
SG044	18.0	1.1									0.0
SG045	19.0	2.2									0.0
SG046	18.0	3.0		2.0							2.0
SG047	14.0	1.9									0.0
SG048	20.0	1.9									0.0
SG049	21.0	2.0			29.0						29.0
SG050	20.0	1.8			590.0	3.0					593.0
SG051	20.0	ND			16.0						16.0
SG052	20.0	3.0	20.0	13.0	79.0		3.0				115.0
SG053	18.0	1.8			370.0						370.0
SG054	20.0	2.6			7.5						7.5
SG055	18.0	ND									0.0
SG056	21.0	ND									0.0
SG057	22.0	ND									0.0
SG058	21.0	ND									0.0
SG059	20.0	ND									0.0
SG060	21.0	ND									0.0
SG061	21.0	ND									0.0
SG062	15.0	ND									0.0

Table 6-4 (continued)
Soil Gas Results - FWA - Former Depot Area - Warehouse Buildings 505, 506, and 507/OMS

Sample	O_2(%)	CO_2(%)	Acetone	Ethyl-benzene	Tetra-chloro-ethene	Trichloro-ethene	m+p-Xylenes	o-Xylene	Benzene	cis-1,2-Dichloro-ethene	Total VOCs
SG063	21.0	ND									0.0
SG064	21.0	ND									0.0
SG065	15.0	8.9			190.0					31.0	221.0
SG066	19.0	2.3	11.0		1800.0	12.0	9.0	4.0			1836.0
SG067	22.0	1.2			10.0	1.4					11.4
SG068	21.0	ND		3.0							3.0
SG069	3.7	9.5			3.0	38.0				62.0	103.0
SG070	20.0	ND									0.0
SG071	3.4	4.4									0.0
SG072	6.2	3.5			2.2						2.2
SG073	15.0	4.6	22.0								22.0
SG074	15.0	4.3		1.7			4.2				5.9
SG075	19.0	5.8	39.0								39.0
SG076	21.0	22.0	12.0								12.0
SG077	18.0	1.7			12.0						12.0
SG078	12.0	3.5	18.0								18.0
SG079	15.0	4.5									0.0
SG080	9.0	11.0									0.0
SG081	6.7	11.0	27.0	8.5							35.5
SG082	18.0	1.2		1.0							1.0
SG083	17.0	ND									0.0
SG084	17.0	3.5									0.0
SG085	21.0	ND									0.0
SG086	17.0	5.0	19.0								19.0
SG087	4.4	ND									0.0
SG088	21.0	1.7									0.0
SG097	21	1.8									0.0
SG098	20	3.5									0.0
SG099	21	ND									0.0

Table 6-4 (continued)
Soil Gas Results - FWA - Former Depot Area - Warehouse Buildings 505, 506, and 507/OMS

Sample	O_2(%)	CO_2(%)	Acetone	Ethyl-benzene	Tetra-chloro-ethene	Trichloro-ethene	m+p-Xylenes	o-Xylene	Benzene	cis-1,2-Dichloro-ethene	Total VOCs
SG100	11	13									0.0
SG101	NC	NC			9.0						9.0
SG102	15	ND	67.0	1.0							68.0
SG103	16	1.7									0.0
SG104	17	ND	57.0		108.0						165.0
SG105	21	1.8	62.0	2.0			3.0				67.0
SG106	21	ND			8.0						8.0
SG107	21	1	30.0		60.0						90.0
SG108	21	1.1	20.0	1.0	26.0		3.0				50.0
SG109	20	2.6			1100.0	43.0					1143.0
SG110	21	ND			1100.0	44.0					1144.0
SG111	19	1.9			2100.0	84.0				1.0	2185.0
SG112	19	2.4			61.0						61.0
SG113	14	6.7			7.0						7.0
SG114	21	1			18.0						18.0
SG115	21	1.2			200.0						200.0
SG116	20	1.1			130.0	7.0					137.0
SG117	21	ND	120.0	3.0	220.0	12.0			1.0		356.0
SG118	18	2.9	120.0		1900.0	80.0					2100.0
SG119	20	2.2	30.0		320.0						350.0
SG120	18	1.2			65.0	1.0					66.0
SG121	17	3.5			260.0	23.0				1.0	284.0
SG122	19	ND	33.0		1300.0	86.0				6.0	1425.0
SG123	18	ND	19.0		330.0	14.0					363.0
SG124	17	ND			77.0	2.0					79.0
SG125	13	ND			150.0	3.0					153.0
SG126	17	1.3		1.0	960.0	7.0					968.0
SG127	17	ND			340.0						340.0
SG128	18	ND	76.0		81.0						157.0

Table 6-4 (continued)
Soil Gas Results - FWA - Former Depot Area - Warehouse Buildings 505, 506, and 507/OMS

Sample	O_2(%)	CO_2(%)	Acetone	Ethyl-benzene	Tetra-chloro-ethene	Trichloro-ethene	m+p-Xylenes	o-Xylene	Benzene	cis-1,2-Dichloro-ethene	Total VOCs
SG129	5.9	7.3									0.0
SG130	15	2.4									0.0
SG131	19	1.3		3.0							3.0
SG132	6.2	ND			24.0						24.0
SG133	17	ND	50.0		200.0	3.0					253.0
SG134	12	ND									0.0
SG148	20	ND	23								23.0
SG149	13	ND	48		40						88.0
SG150	20	ND	11		3						14.0
SG151	20	ND			6						6.0
SG152	17	ND			66						66.0
SG153	20	ND	11		24						35.0
SG154	21	ND			1						1.0
SG155	21	1			17						17.0
SG156	12	ND			13						13.0
SG157	19	ND			5						5.0
SG158	14	3.1			4						4.0
SG159	19	2.3			4.3						4.3
SG160	18	3.3			17						17.0
SG161	17	3.5			2.1						2.1
SG162	21	ND			58						58.0
SG163	21	ND	26		190	9					225.0
SG164	21	1.4	22		110	19					151.0
SG165	21	ND			91	5					96.0
SG166	21	ND			7						7.0
SG167	20	ND	64		16						80.0
SG168	21	ND									0.0
SG169	20	ND			4.6						4.6
SG170	18	ND									0.0

Table 6-4 (continued)
Soil Gas Results - FWA - Former Depot Area - Warehouse Buildings 505, 506, and 507/OMS

Sample	O_2(%)	CO_2(%)	Acetone	Ethyl-benzene	Tetra-chloro-ethene	Trichloro-ethene	m+p-Xylenes	o-Xylene	Benzene	cis-1,2-Dichloro-ethene	Total VOCs
SG171	17	ND	33								33.0
SG172	18	ND			2.1						2.1
SG173	19	ND			5						5.0
SG174	18	ND			16						16.0
SG177	22	ND									0.0
SG178	20	1.4									0.0
SG179	21	ND			410						410.0
SG180	22	ND									0.0
SG181	21	ND									0.0
SG182	21	ND	30		8						38.0
SG183	20	1.1			7						7.0
SG184	21	ND									0.0
SG185	19	3.1	45		2.9						47.9
SG186	17	5.6	59		25						84.0
SG187	21	ND	59		17						76.0
SG188	21	ND			1.7						1.7
SG189	21	ND									0.0
SG193	16	ND									0.0
SG194	19	ND	52		1.5						53.5
SG195	18	ND			2.6						2.6
SG196	20	ND	23		5.5						28.5
SG197	19	ND	41		10						51.0
SG198	20	ND									0.0
SG199	19	ND			1.1						1.1
SG200	19	ND	62		8.3						70.3

Note:

All organic concentrations in μg/l (vol).
Blank space implies compound not reported.
ND-not reported.
NC-not calculated.

Figure 6-17
FWA Site Investigation
Former Depot Area - Warehouse Buildings 505, 506, and 507/OMS
Soil Gas Sampling Locations

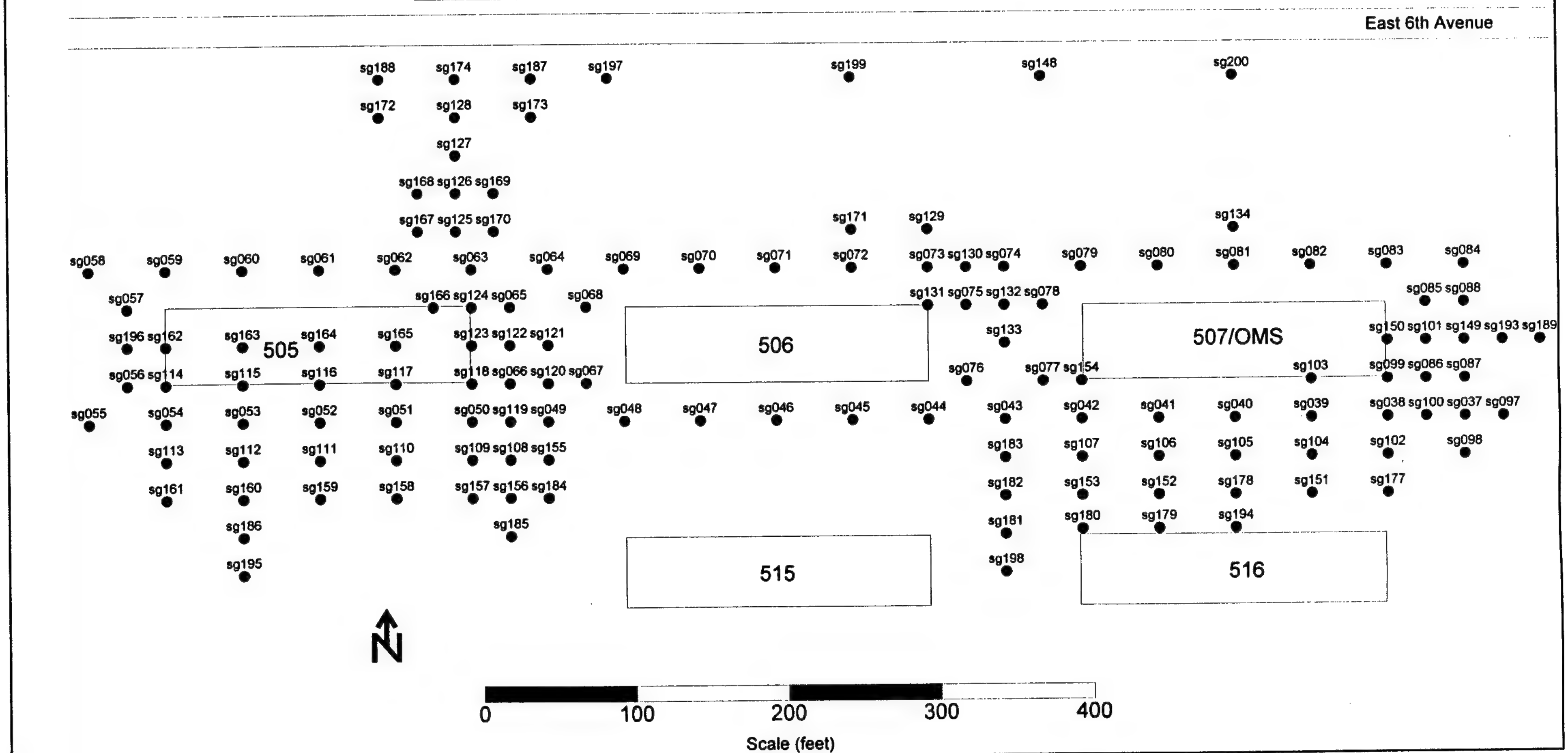


Figure 6-18
FWA Site Investigation
Former Depot Area - Warehouse Buildings 505, 506, and 507/OMS
Acetone Concentrations (μg/l air)

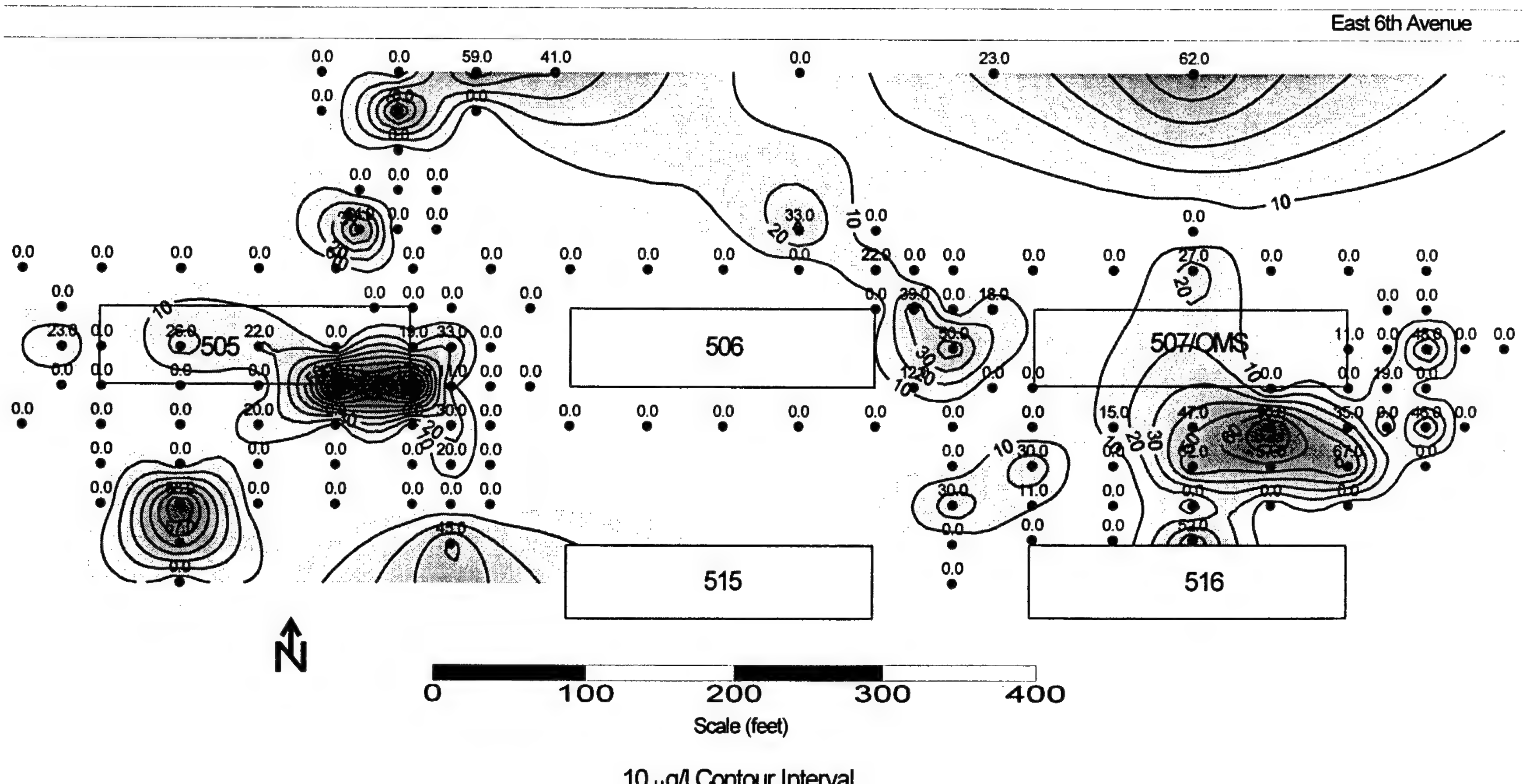


Figure 6-19
FWA Site Investigation
Former Depot Area - Warehouse Buildings 505, 506, and 507/OMS
PCE Concentrations (μg/l air)

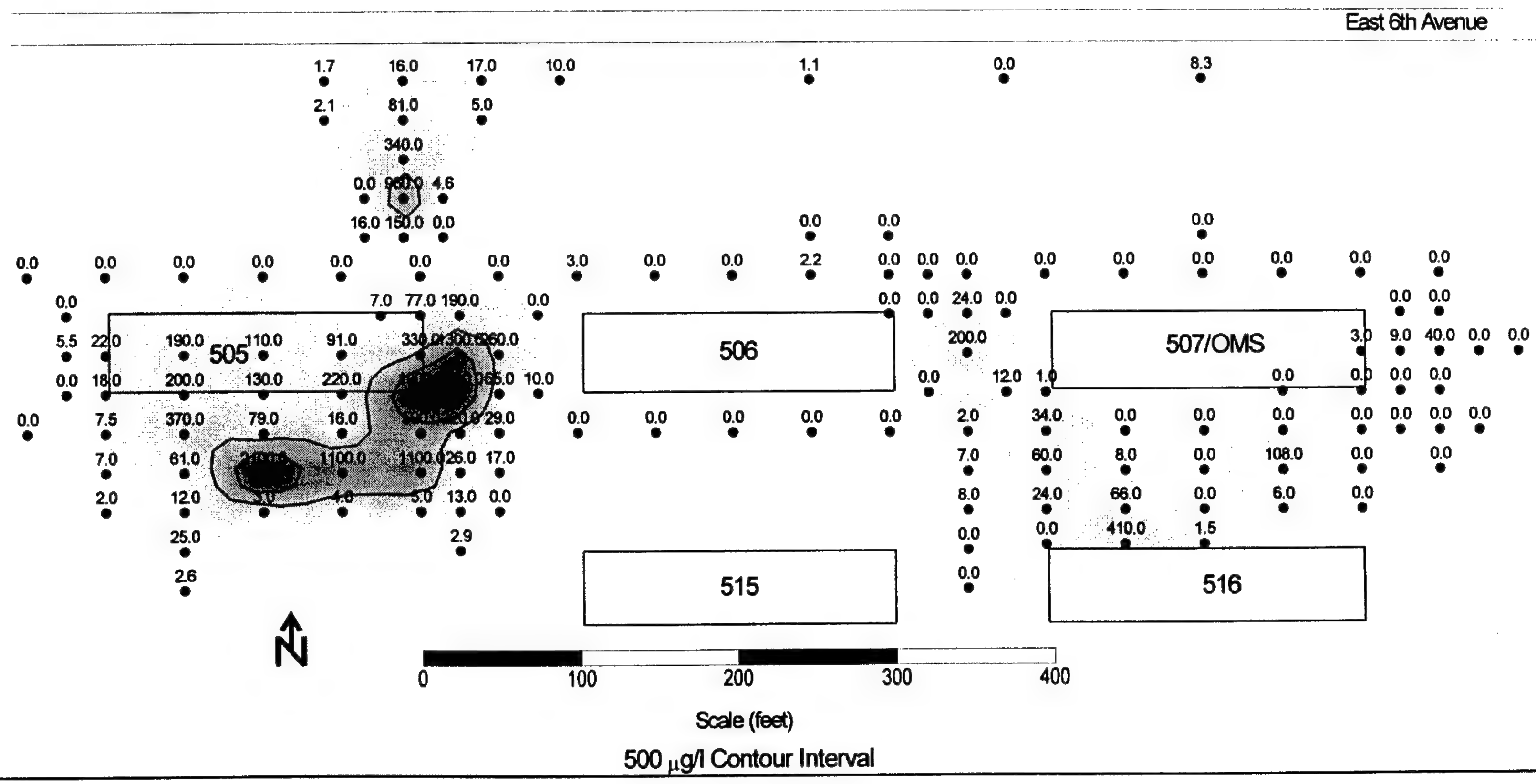
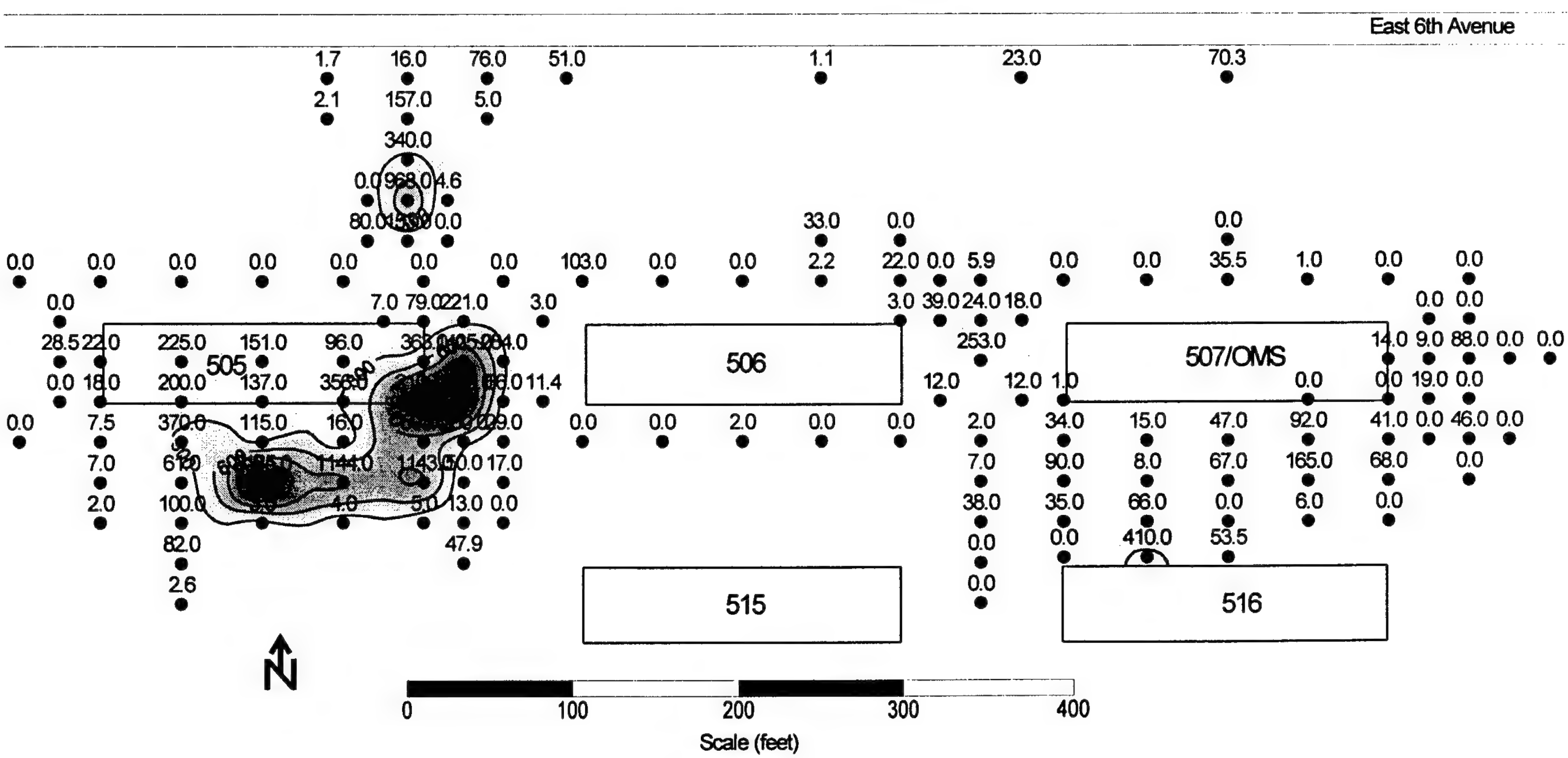


Figure 6-20
FWA Site Investigation
Former Depot Area - Warehouse Buildings 505, 506, and 507/OMS
Total VOCs Concentration (µg/l air)



300 µg/l Contour Interval

6.4 BACKGROUND SURFACE SOIL SAMPLES

Two surface soil background samples were obtained at the FWA investigation area. Background soil samples, FWASB21 and FWASB22, were collected adjacent to upgradient monitoring well boring location FWAMW05 and FWAMW01, respectively. Soil samples were collected from a depth of 0 to 0.5 ft bgs. Two duplicate soil samples (FWASB35 and FWASB36) were collected, one from each background location. All background soil samples were analyzed for VOCs, SVOCs, EPH, VPH, pesticides, herbicides, PCBs, PP metals, and percent moisture. Background soil boring locations are presented in Figure 6-21. All analytes reported in background soils equal to or above the method detection limit are presented in Table 6-5.

Both organic and metal analytes were reported in background soil samples. Acetone, methylene chloride, benzoic acid, bis(2-ethylhexyl)phthalate, EPH, and xylenes were reported in background soils at low concentrations above and below method detection limits. Pesticides, herbicides, PCBs, antimony, mercury, and selenium were not reported in background soils above method detection limits.

Table 6-6 provides a comparison between the maximum FWA background soil metal concentrations and concentration ranges for those metals reported in the western United States (USGS, 1984). This comparison indicates that none of the reported metal analytes, except for cadmium and silver, are above the range of background metals reported in the western United States. A comparison for cadmium and silver can not be made because western United States concentration ranges are not available.

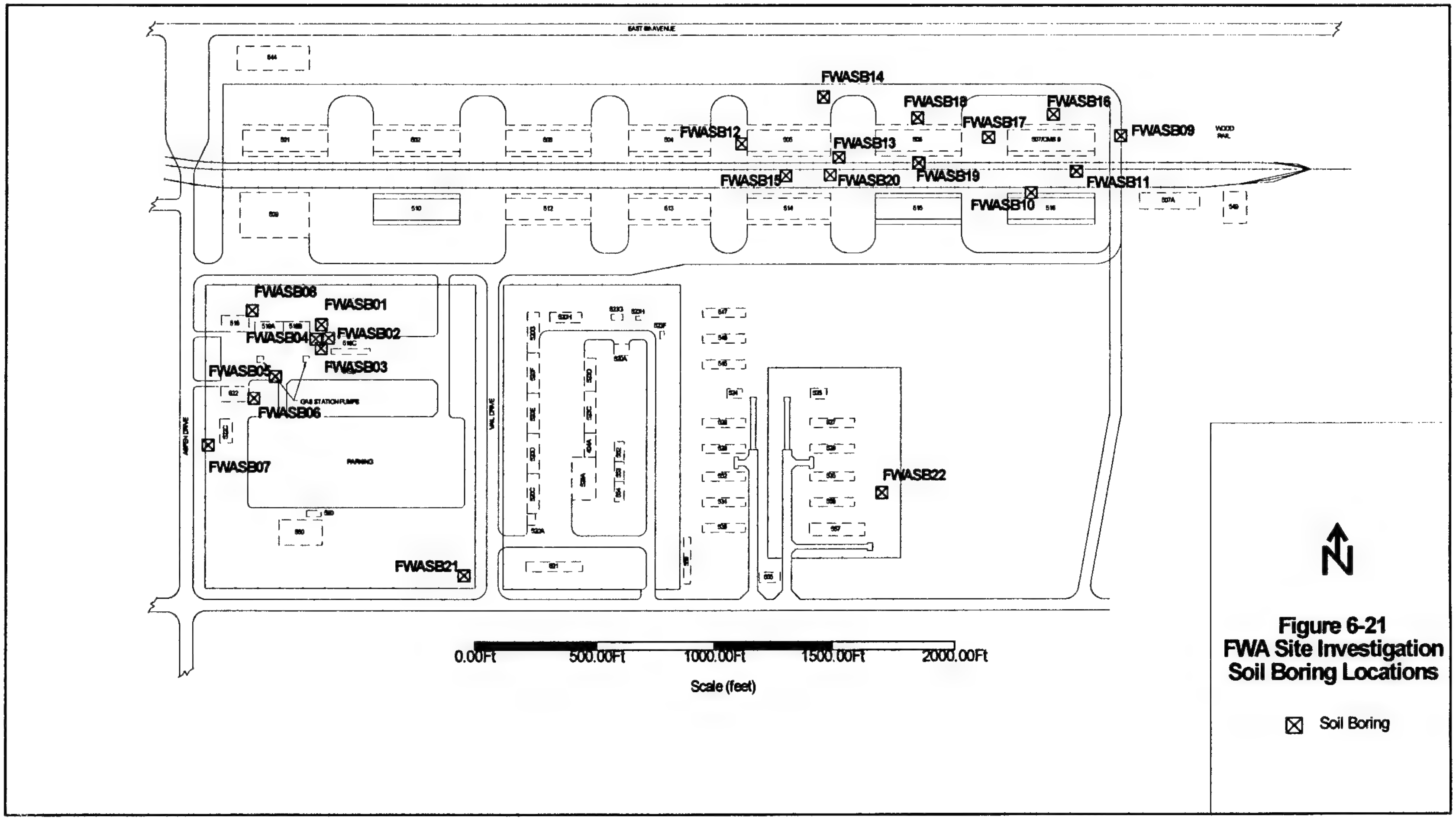


Figure 6-21
FWA Site Investigation
Soil Boring Locations

Table 6-5 Background Surface Soil Sample Analytical Results FWA Site Investigation				
Analyte	**FWASB21-00**	**FWASB22-00**	**FWASB35-00**	**FWASB36-00**
ACETONE			13 µg/kg	
BENZOIC ACID			51 J µg/kg	
BIS(2-ETHYLHEXYL)PHTHALATE		45 J µg/kg		
M,P-XYLENES			0.82 J µg/kg	
METHYLENE CHLORIDE	7.4 µg/kg			9.6 µg/kg
O-XYLENE			0.79 J µg/kg	
EPH			64 mg/kg	
ARSENIC, TOTAL	1.9 JL mg/kg	2.2 JL mg/kg	2.6 mg/kg	2.3 JL mg/kg
BERYLLIUM		1.0 mg/kg	0.81 mg/kg	0.97 mg/kg
CADMIUM			0.96 mg/kg	
CHROMIUM	8.5 JH mg/kg	19 JH mg/kg	13 JH mg/kg	18 JH mg/kg
COPPER	9.0 JH mg/kg	19 JH mg/kg	19 mg/kg	18 JH mg/kg
LEAD, TOTAL	22 JH mg/kg	21 JH mg/kg	64 mg/kg	25 JH mg/kg
NICKEL	8.5 mg/kg	15 mg/kg	12 mg/kg	14 mg/kg
SILVER			0.63 mg/kg	0.69 mg/kg
THALLIUM, TOTAL	0.13 mg/kg	0.20 mg/kg	0.23 mg/kg	0.16 mg/kg
ZINC	32 JH mg/kg	70 JH mg/kg	67 JH mg/kg	68 JH mg/kg
PERCENT MOISTURE	8.70 %	14.0 %	8.60 %	14.2 %

Note: Sample FWASB35 is duplicate of FWASB21.
Sample FWASB36 is duplicate of FWASB22.
J - estimated value.
JH - estimated high value.
JL - estimated low value.
Blanks indicates analyte not reported at method detection limit.

Table 6-6 Comparison of FWA Background and Western U.S. Metals Concentrations		
Metal	**FWA Maximum Background Value (mg/kg)**	**Concentration Range in Western U.S. (mg/kg)+**
Antimony	< 5.8 *	< 1 - 2.6
Arsenic	2.6	<0.10 - 97
Beryllium	1.0	<1 - 15
Cadmium	0.96	NA
Chromium	19	3 - 2,000
Copper	19	2 - 300
Lead	64	<10 - 700
Mercury	<0.12 *	<0.01 - 4.6
Nickel	15	<5 - 700
Selenium	<1.1 *	<0.1 - 4.3
Silver	0.69	NA
Thallium	0.23	0.05 -2.0
Zinc	70	10 - 2,100

Note: NA - not available
* - not reported at shown detection limit
+ - USGS, 1984

6.5 DIRECT PUSH SOIL SAMPLE RESULTS

Twenty soil borings were advanced at the FWA investigation area, 8 borings were located at the Former AF Motor Pool area, and 12 borings were located at the Former Depot area on and around the vicinity of Former Warehouses 505, 506, and 507/OMS. Direct push techniques were used to collect soil samples from the surface, middle, and bottom of each soil boring for chemical analysis. The locations of the soil borings were based on results of the geophysical survey and soil gas field screening results. Soil samples were analyzed for halogenated VOCs, SVOCs, EPH, VPH, and PP metals. Additional analyses for pesticides, herbicides, and PCBs were performed on selected soil samples collected from the Former Depot area. Soil boring locations for the entire FWA is presented in Figure 6-21.

A total of 60 soil samples and 4 duplicate samples were collected from the 20 soil boring locations. Laboratory data analysis summary sheets for all soil samples are presented in Appendix H. A tabulation of all sample results are presented in Appendix I. Geologic logs of each soil boring are presented in Appendix B.

6.5.1 Former AF Motor Pool Area Soil Sample Results

Figure 6-22 presents the location of the eight borings performed in the vicinity of the Former AF Motor Pool area. Three soil samples were collected from each boring. Boring FWASB01, the deepest boring, was completed as a continuous boring to a depth of 34 ft bgs; however, most borings were completed to a depth of 16 to 18 ft bgs.

6.5.1.1 Former AF Motor Pool Area Surface Soil Sample Results

Surface soil samples were collected from a depth of 0 to 0.5 ft bgs at each boring location. Samples were collected up to a depth of 6 ft bgs when poor sample recovery was encountered or if additional sample amounts were needed for laboratory analyses.

6.5.1.1.1 Former AF Motor Pool Area Surface Soil VOC Analytical Results

Acetone, methylene chloride, toluene, and xylenes were reported in surface soils. Acetone was reported in concentrations ranging from 16 μg/kg to 7,000 μg/kg at all soil boring locations except for boring locations FWASB07 and FWASB08. Acetone concentrations of 1,700 μg/kg or less are attributed to in field contamination resulting from the coelution of isopropanol used in decontaminating field equipment. Methylene chloride, possibly associated with laboratory contamination, was reported at a concentration of 23 μg/kg at boring location FWASB03. Toluene was reported at a low concentration of 0.61 μg/kg at boring location FWASB05. Xylenes, ranging in concentration from 1.4 μg/kg to 0.75 μg/kg, were reported at boring locations FWASB07 and FWASB08. VOCs were not reported above the method detection limit in any other surface soil samples. Table 6-7 presents a tabular summary of surface soil VOC analytical results. Figure 6-23 illustrates the distribution of surface soil VOCs at the Former AF Motor Pool area.

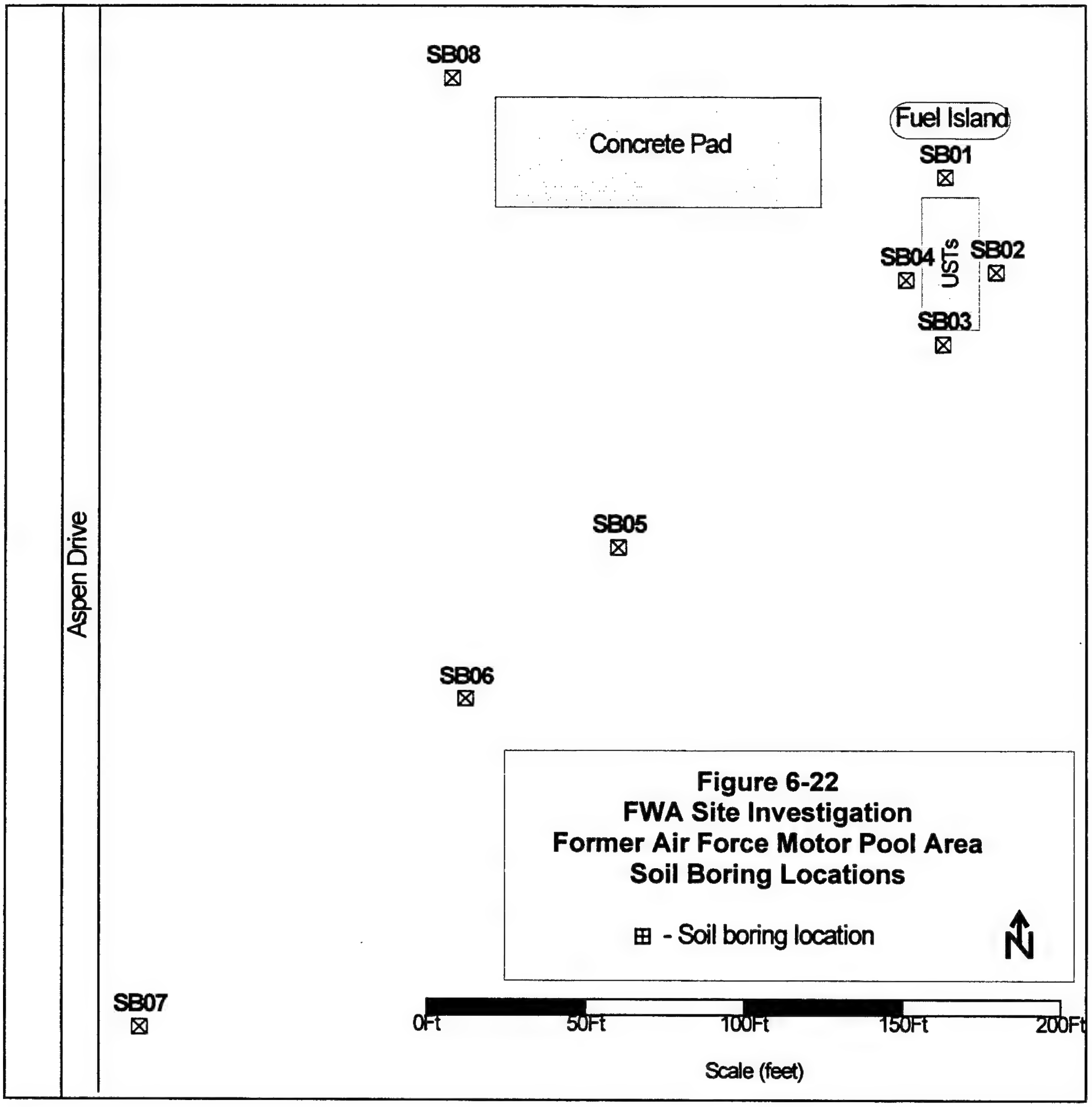


Figure 6-22
FWA Site Investigation
Former Air Force Motor Pool Area
Soil Boring Locations

Table 6-7
Surface Soil VOC Summary
FWA Site Investigation
Former Air Force Motor Pool Area

Sample	Acetone	M,P-Xylenes	Methylene Chloride	O-Xylene	Toluene
FWASB01-00	110 *				
FWASB02-00					
FWASB03-00	530 D *		23 **		
FWASB04-00					
FWASB05-00	16 *				0.61 J
FWASB06-00	7000 D				
FWASB07-00		0.75 J		1.4	
FWASB08-00		0.98 J			
FWASB34-00	13 *				

Note: VOC concentrations in µg/kg.
* - Likely attributed to coelution of isopropanol used in decontaminating field equipment.
** - Likely attributed to laboratory contamination.
FWASB34-00 duplicate of FWASB06-00
D - analyte was diluted.
J - estimated value.
Blanks indicate analyte not reported at method detection limit.

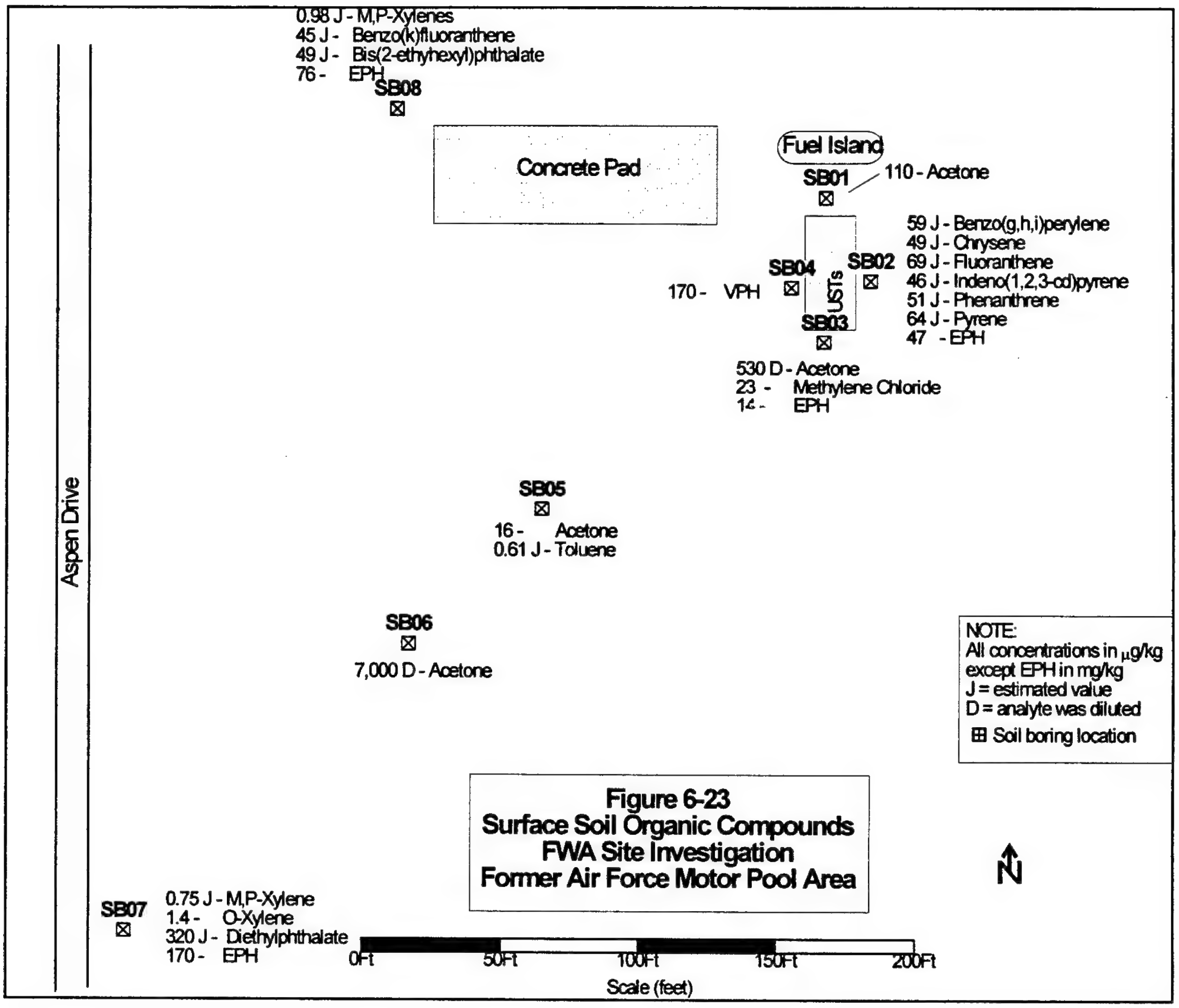


Figure 6-23
Surface Soil Organic Compounds
FWA Site Investigation
Former Air Force Motor Pool Area

6.5.1.1.2 Former AF Motor Pool Area Surface Soil SVOC Analytical Results

SVOCs were reported at three soil boring locations in the vicinity of the Former AF Motor Pool area. Low concentrations of benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene were reported at soil boring FWASB02 located on the east side of the USTs. These compounds are typically associated with coal tar derivatives, asphalt, or burned wood. Diethylphthalate was reported at soil boring FWASB07 at a concentration of 320 μg/kg. Benzo(k)fluoranthene and bis(2-ethylhexyl)phthalate were reported at soil boring FWASB08 at concentration of 45 μg/kg and 49 μg/kg, respectively. SVOCs were not reported in any remaining surface soil samples above the method detection limit. Table 6-8 presents a tabular summary of surface soil SVOC analytical results. Figure 6-23 illustrates the distribution of surface soil SVOCs at the Former AF Motor Pool area.

6.5.1.1.3 Former AF Motor Pool Area Surface Soil EPH and VPH Analytical Results

EPHs were reported at soil boring locations FWASB02, FWASB03, FWASB07, and FWASB08 in concentrations ranging from 14 to 170 μg/kg. VPHs were reported at soil boring FWASB04 at a concentration of 170 μg/kg. EPHs and VPHs were not reported in any remaining surface soil samples above the method detection limit. Table 6-9 presents a tabular summary of surface soil EPH and VPH analytical results. Figure 6-23 illustrates the distribution of surface soil SVOCs at the Former AF Motor Pool area.

6.5.1.1.4 Former AF Motor Pool Area Surface Soil PP Metals Analytical Results

Several metals were reported in surface soil samples collected from the Former AF Motor Pool area, including arsenic, beryllium, cadmium, chromium, copper, lead, nickel, silver, thallium, and zinc. All these metals, except for chromium and silver, were reported at concentrations equal to or greater than the local background surface soil samples at the Former AF Motor Pool area. However, concentrations of metals reported were all within the ranges for those metals reported in the western United States. Antimony, mercury, and selenium were not reported in any surface soil samples above the method detection limit. Detailed results of metals analyses are presented in Appendix I. Figure 6-24 presents all reported soil boring surface soil metals at the Former AF Motor Pool area. All surface soil samples with metal concentrations equal to or greater than local background soil samples are illustrated in Figure 6-25 and listed in Table 6-10.

6.5.1.2 Former AF Motor Pool Area Subsurface Soil Sample Results

Subsurface soil samples were collected from approximately the middle and bottom of each boring for chemical analysis. A total of 16 subsurface soil samples were collected in intervals ranging from 2 to 4 ft.

Table 6-8
Surface Soil SVOC Summary
FWA Site Investigation
Former Air Force Motor Pool Area

Sample	Benzo-(g,h,I)-Perylene	Benzo(k)-Fluoranthene	Bis(2-Ethylhexyl)-Phthalate	Chrysene	Di-n-butyl-Phthalate	Di-ethyl-phthalate	Fluor-anthene	Indeno (1,2,3-cd)-Pyrene	Phenanthrene	Pyrene
FWASB02-00	59 J			49 J			69 J	46 J	51 J	64 J
FWASB07-00						320 J				
FWASB08-00		45 J	49 J							
FWASB34-00					58 J					

Note: SVOC concentrations in µg/kg.
FWASB34-00 duplicate of FWASB06-00.
J - estimated value.
Blanks indicate analyte not reported at method detection limit.

Table 6-9 Surface Soil EPH and VPH Summary FWA Site Investigation Former Air Force Motor Pool Area		
Sample	**EPH**	**VPH**
FWASB02-00	47	
FWASB03-00	14	
FWASB04-00		170
FWASB07-00	170	
FWASB08-00	76	
FWASB33-00	83	

Note: EPH concentrations in mg/kg.
VPH concentrations in µg/kg.
FWASB33-00 is duplicate of FWASB07-00.
Blanks indicates analyte not reported at method detection limit.

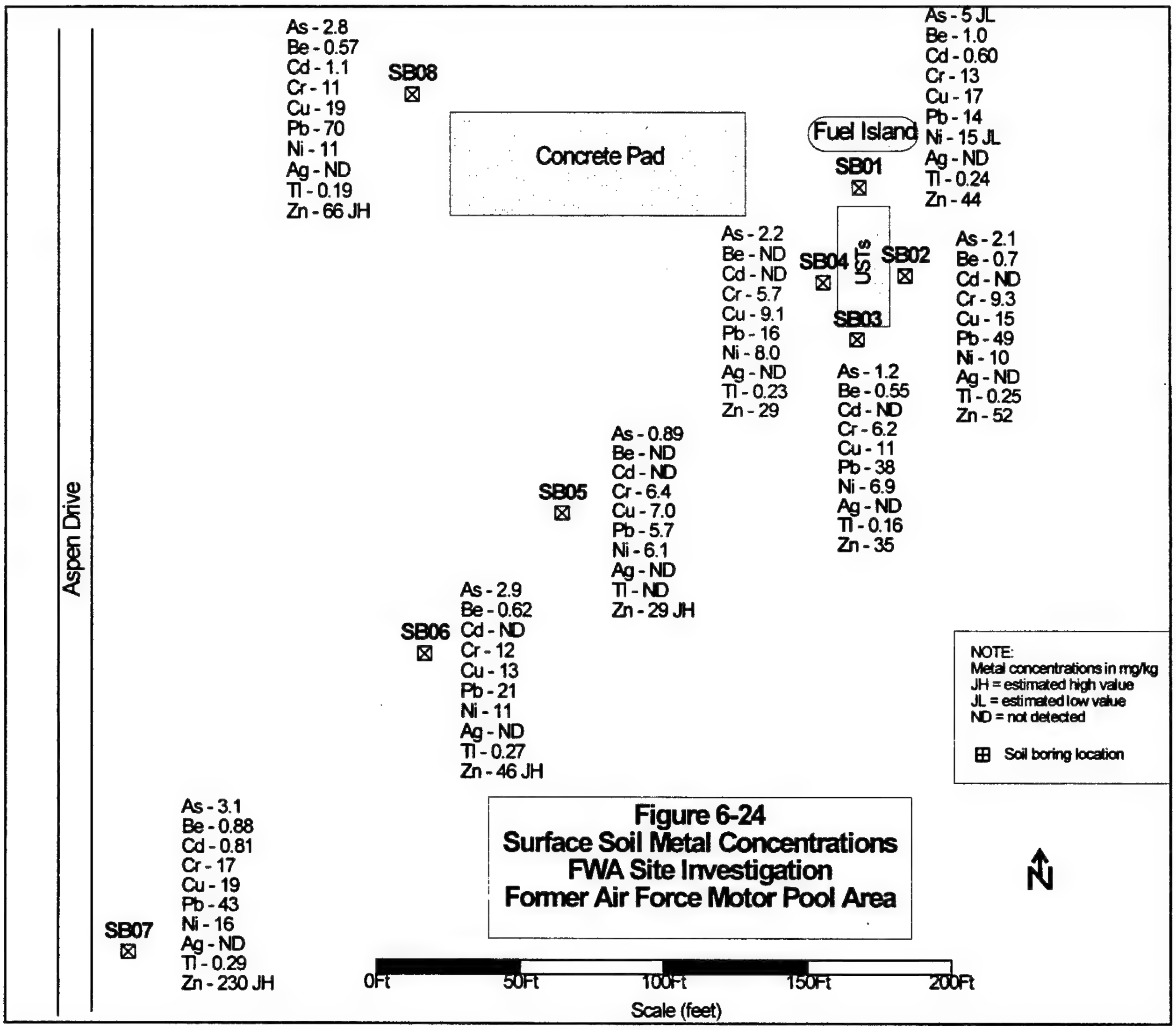


Figure 6-24
Surface Soil Metal Concentrations
FWA Site Investigation
Former Air Force Motor Pool Area

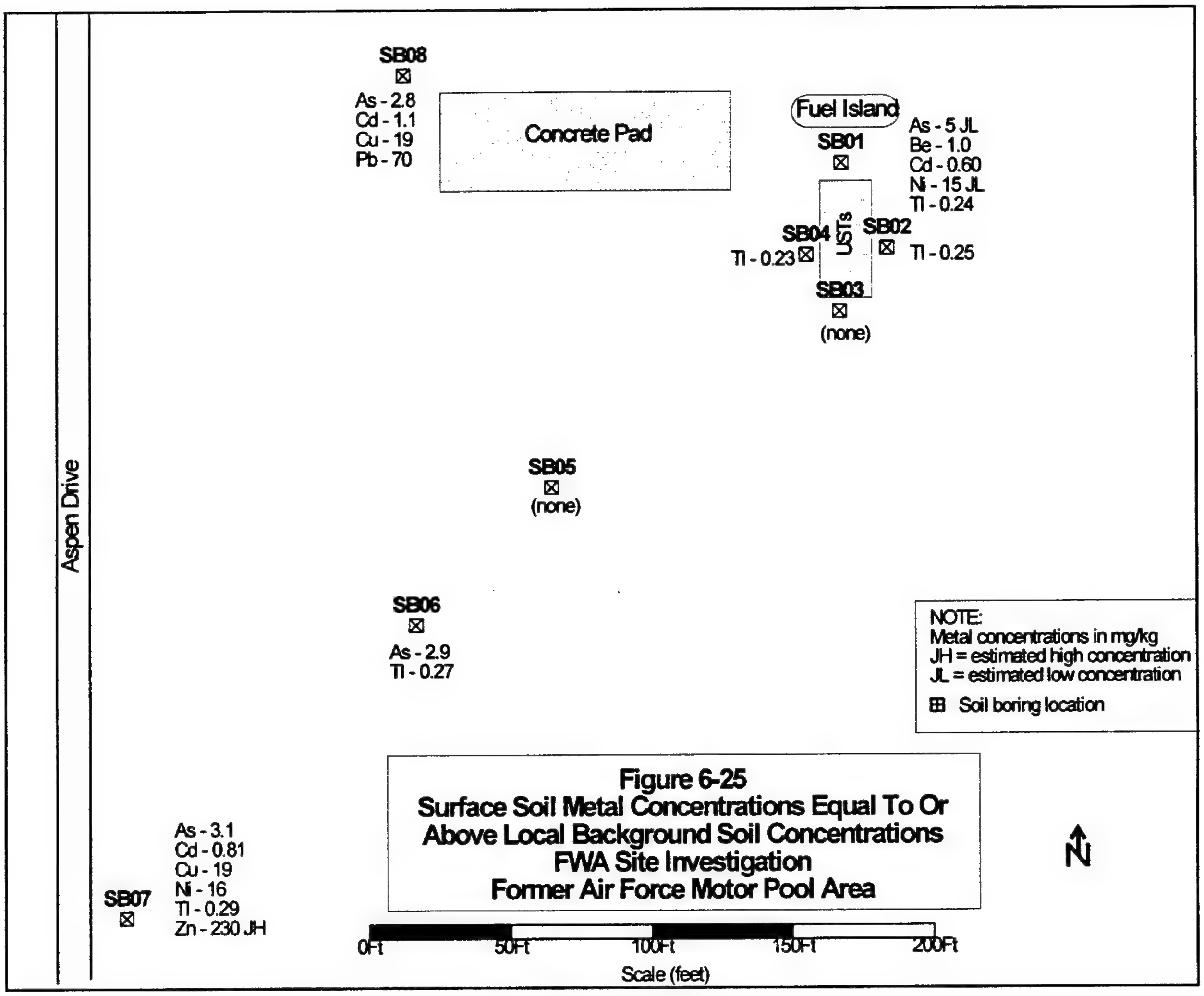


Figure 6-25
Surface Soil Metal Concentrations Equal To Or Above Local Background Soil Concentrations
FWA Site Investigation
Former Air Force Motor Pool Area

Table 6-10
Surface Soil Samples with Metal Concentrations Greater or Equal to Local Surface Soil Background
FWA Site Investigation
Former Air Force Motor Pool Area

Sample	Arsenic, total	Beryllium	Cadmium	Chromium	Copper	Lead, total	Mercury, total	Nickel	Silver	Zinc
FWASB01-00	5 JL	1						15 JL		
FWASB02-00							0.2		0.88	
FWASB06-00	2.9									
FWASB07-00	3.1				19			16		230 JH
FWASB08-00	2.8		1.1		19	70				

Note: Metal concentrations in mg/kg.
J - estimated value.
JH - estimated high value.
JL - estimated low value.

6.5.1.2.1 Former AF Motor Pool Area Subsurface Soil VOC Analytical Results

VOCs including acetone, methylene chloride, ethylbenzene, xylenes, and 2-butanone were reported in subsurface soils at the Former AF Motor Pool area. Acetone was the most prevalent VOC and was reported in 11 soil samples, ranging in concentration from 23 μg/kg to 3,700 μg/kg. Acetone concentrations of 1,700 μg/kg or less are attributed to in field contamination resulting from the coelution of isopropanol used in decontaminating field equipment. Methylene chloride, contributed to laboratory contamination, was reported in five soil samples in concentrations ranging from 13 to 33 μg/kg. Ethylbenzene, ranging in concentration from 99 μg/kg to 330 μg/kg, was reported in two soil samples. Xylenes were reported in two soil samples, ranging in concentration from 26 μg/kg to 1,400 μg/kg. One sample contained 2-butanone at a concentration of 270 μg/kg.

The highest concentration of total VOCs was reported at a depth of 9 to 11 ft bgs at soil boring FWASB04 located on the western side of the USTs. A strong petroleum odor and visible soil staining was observed at this sample interval. Significant VOCs were also reported at 18 to 20 ft bgs at soil boring FWASB04 and from 16 to 18 ft bgs at soil boring FWASB05. Staining and/or a strong petroleum odor was also reported at these sample intervals. Table 6-11 presents all reported VOCs from Former AF Motor Pool area subsurface soil samples. Figure 6-26 illustrates the distribution of subsurface soil VOCs at the Former AF Motor Pool area.

6.5.1.2.2 Former AF Motor Pool Area Subsurface Soil SVOC Analytical Results

Eighteen SVOC compounds were reported in subsurface soils at the Former AF Motor Pool area. These compounds included 2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenz(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene, chrysene, and di-n-butylphthalate. SVOCs were reported only at soil borings FWASB01, FWASB04, and FWASB05. The compound 2-methylnaphthalene is reported at all three borings, ranging in concentration from 96 μg/kg to 4,100 μg/kg. The highest concentration of SVOCs were reported at soil boring FWASB04 located on the western side of the USTs at a depth of 9 to 11 ft bgs. A significant concentration of SVOCs were also reported at soil boring FWASB05 at a depth of 16 to 18 ft bgs. Both of these soil samples exhibited soil staining with a strong petroleum odor. Table 6-12 presents a tabular summary of subsurface soil SVOC analytical results. Figure 6-26 illustrates the distribution of subsurface soil SVOCs at the Former AF Motor Pool area.

6.5.1.2.3 Former AF Motor Pool Area Subsurface Soil EPH and VPH Analytical Results

EPHs were reported at soil borings FWASB04 (9 to 11 ft bgs) and FWASB05 (16 to 18 ft bgs) in concentrations of 120 mg/kg and 19 mg/kg, respectively. VPH were reported at soil boring FWASB01 (12 to 14 ft bgs), FWASB04 (9 to 11 ft bgs) and FWASB05 (16 to 18 ft bgs) in concentrations of 71,000 μg/kg, 49,000 μg/kg, and 72,000 μg/kg, respectively. Table 6-13 presents a tabular summary of Former AF Motor Pool area subsurface soil EPH and VPH concentrations. The distribution of EPHs and VPHs within subsurface soils are presented in Figure 6-26.

Table 6-11
Subsurface Soil VOC Summary
FWA Site Investigation
Former Air Force Motor Pool Area

Sample	2-butanone	Acetone	Ethylbenzene	M,P-Xylenes	Methylene Chloride	O-Xylene
FWASB01-12		2700 D				
FWASB02-10					30 **	
FWASB02-20					25 **	
FWASB03-08					19 **	
FWASB03-16		3700 D			13 **	
FWASB04-09		3300	330 D JH	1400 D JH		58 D JH
FWASB04-18		3000 D			33 **	
FWASB05-08		42 *				
FWASB05-16	270 D	520 D *	99 D	98 D		26 D
FWASB06-08		20 *				
FWASB06-16		33 *				
FWASB07-09		170 *				
FWASB07-18		200 *				
FWASB08-16		31 *				
FWASB30-20		31 *			27 **	

Note: VOC concentrations in µg/kg.
* - Likely attributed to coelution of isopropanol used in decontaminating field equipment.
** - Likely attributed to laboratory contamination.
FWASB30-20 is duplicate of FWASB02-20.
D - analyte was diluted.
JH - estimated high value.
Blanks indicate analyte not reported at method detection limit.

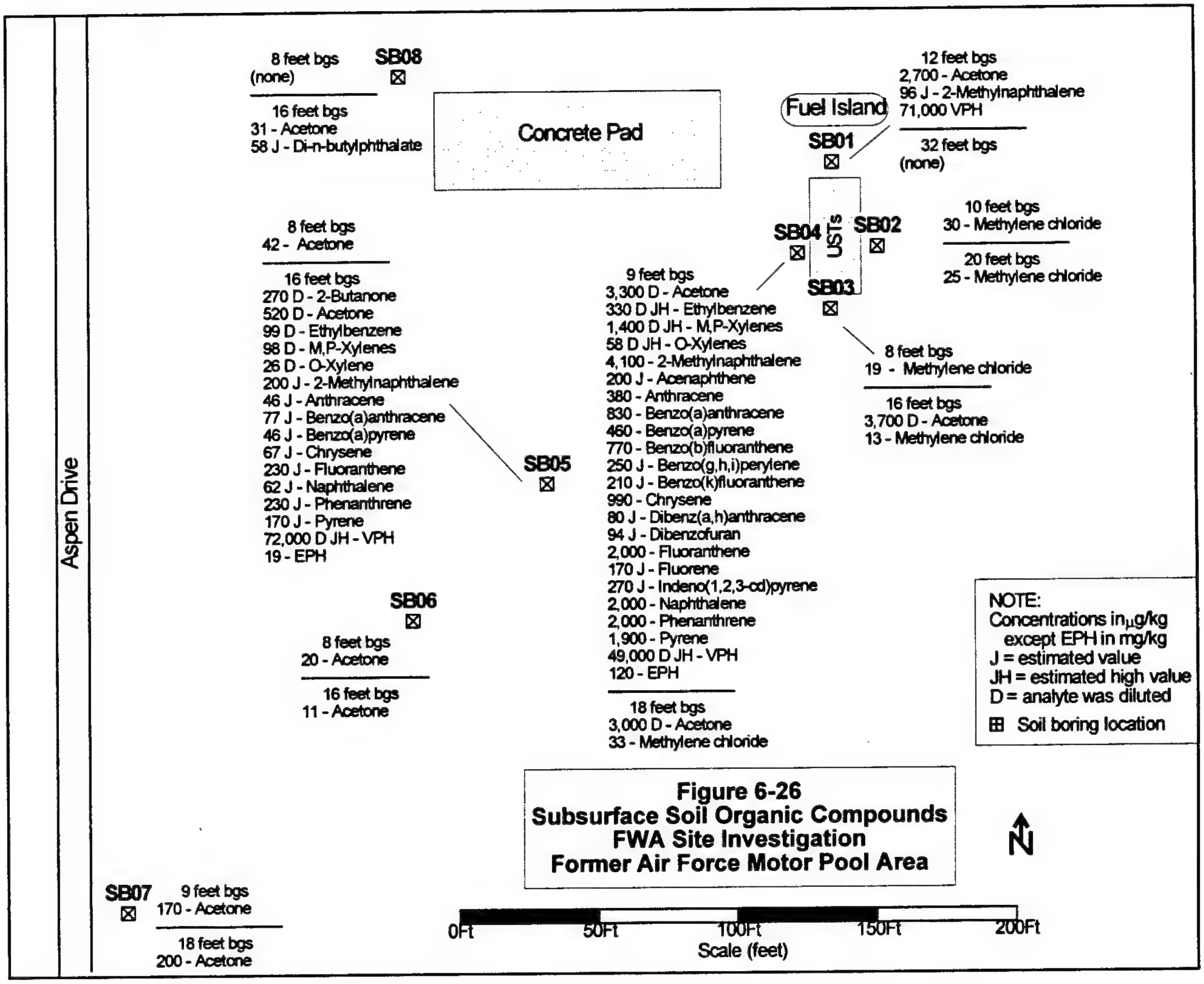


Figure 6-26
Subsurface Soil Organic Compounds
FWA Site Investigation
Former Air Force Motor Pool Area

Table 6-12
Subsurface Soil SVOC Summary
FWA Site Investigation
Former Air Force Motor Pool Area

Analyte	FWASB01-12	FWASB04-09	FWASB05-16	FWASB08-16
2-METHYLNAPHTHALENE	96 J	4100	200 J	
ACENAPHTHENE		200 J		
ANTHRACENE		380	56 J	
BENZO(A)ANTHRACENE		830	77 J	
BENZO(A)PYRENE		460	46 J	
BENZO(B)FLUORANTHENE		770		
BENZO(G,H,I)PERYLENE		250 J		
BENZO(K)FLUORANTHENE		210 J		
BUTYLBENZYLPHTHALATE				
CHRYSENE		990	67 J	
DI-N-BUTYLPHTHALATE				58 J
DIBENZ(A,H)ANTHRACENE		80 J		
DIBENZOFURAN		94 J		
FLUORANTHENE		2000	230 J	
FLUORENE		170 J		
INDENO(1,2,3-CD)PYRENE		270 J		
NAPHTHALENE		2000	62 J	
PHENANTHRENE		2000	230 J	
PYRENE		1900	170 J	

Note: SVOCs in µg/mg.
J - estimated value.
Blanks indicate analyte not reported at method detection limit.

Table 6-13 Subsurface Soil EPH and VPH Summary FWA Site Investigation Former Air Force Motor Pool Area		
Sample	**EPH**	**VPH**
FWASB01-12		71000
FWASB04-09	120	49,000 D JH
FWASB05-16	19	72,000 D JH

Note: EPH concentrations in mg/kg.
VPH concentrations in μg/kg.
D - analyte was diluted.
JH - estimated high value.
Blanks indicate analyte not reported at method detection limit.

6.5.1.2.4 Former AF Motor Pool Area Subsurface Soil PP Metals Analytical Results

Several metals were reported in subsurface soil samples collected from the Former AF Motor Pool area, including arsenic, beryllium, cadmium, chromium, copper, lead, nickel, silver, thallium, and zinc. Concentrations of metals reported were all within the concentration ranges for those metals reported in the western United States. Concentrations of subsurface soil metals are similar to surface soil samples collected at the Former AF Motor Pool area. Antimony, mercury, and selenium were not reported in any subsurface soil samples above the method detection limit. A summary of reported subsurface soil metals are presented in Table 6-14. Figure 6-27 illustrates the distribution of subsurface soil metals at the Former AF Motor Pool area.

6.5.2 Former Depot Area Soil Sample Results

Figure 6-28 presents the location of the 12 borings advanced in and around Former Warehouses 505, 506, and 507/OMS in the vicinity of the Former Depot area. Three soil samples were collected from each boring. The deepest boring was completed to a depth of 20 ft bgs; however, most borings were completed to a depth of 14 to 18 ft bgs.

6.5.2.1 Former Depot Area Surface Soil Sample Results

Surface soil samples were collected from a depth of 0 to 0.5 ft bgs at each boring location. Samples were collected up to a depth of 6 ft bgs if poor sample recovery was encountered or if additional sample amounts were needed for laboratory analyses.

6.5.2.1.1 Former Depot Area Surface Soil VOC Analytical Results

Acetone, methylene chloride, toluene, PCE, and 2-butanone were reported in surface soils. Acetone was reported in concentrations ranging from 0.62 μg/kg to 8,020 μg/kg at all soil boring locations except for locations FWASB09 and FWASB15. Methylene chloride was reported at six boring locations, FWASB09, FWASB11, FWASB14, FWASB17, FWASB18, and FWASB20 at concentrations ranging from 4.1 μg/kg to 41 μg/kg. Low concentrations of toluene, ranging from 0.62 μg/kg to 1.3 μg/kg, were reported at soil borings FWASB09, FWASB11, FWASB16, and FWASB17. PCE was reported at soil borings FWASB10, FWASB12, FWASB13, and FWASB14 at concentrations of 360 μg/kg, 10 μg/kg, 43 μg/kg, and 61 μg/kg, respectively. The compound 2-Butanone was reported at a concentration of 82 μg/kg at soil boring FWASB11. No other VOCs were reported in surface soil samples above the method detection limit. Table 6-15 presents all reported VOCs from Former Depot area surface soil samples. Figure 6-29 illustrates the distribution of surface soil VOCs at the Former Depot area.

6.5.2.1.2 Former Depot Area Surface Soil SVOC Analytical Results

Fourteen SVOC compounds were reported in surface soils at the Former Depot area. These compounds included acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene,

Table 6-14
Subsurface Soil Samples with Metal Concentrations Greater or Equal to Method Detection Limit
FWA Site Investigation
Former Air Force Motor Pool Area

Sample	Arsenic, Total	Beryllium	Cadmium	Chromium	Copper	Lead, Total	Nickel	Thallium, Total	Zinc
FWASB01-12	3.2 JL	1.3		12	41	17	18 JL	0.38	99
FWASB01-32	1.7	1.2		4.9	56	16	16	0.30	67
FWASB02-10	4.4	0.78		12	24	14	15	0.41	53
FWASB02-20	3.9	0.90		13	24	12	16	0.29	67
FWASB03-08	1.8	0.56		8.9	16	7.9	10	0.23	41
FWASB03-16	3.3	0.72		14	16	8.1 JL	10	0.26	60
FWASB04-09	2.3	0.66		8.1	16	19	10	0.31	49
FWASB04-18	6.1 JL	0.76		17	17	9.6	9.4	0.26	59
FWASB05-08	2.8	0.75		12	18	11	11	0.31	55 JH
FWASB05-16	7.4	0.68		18	17	9.0	12	0.17	84 JH
FWASB06-08	2.1	0.79		13	18	11	13	0.31	59 JH
FWASB06-16	3.2			8.0	15	6.8	8.2	0.12	45 JH
FWASB07-09	18	0.63	0.63	24	16	7.3	14	0.34	93 JH
FWASB07-18	2.0		0.61	18	13	4.9	14		62 JH
FWASB08-08	1.9	0.76	0.58	9.1	23	11	11	0.29	57 JH
FWASB08-16	0.50	0.69		17	18	9.8	16	0.31	88 JH
FWASB30-20	3.7	0.72		12	22	12	12	0.44	59

Note: Metal concentrations in mg/kg.
FWASB30-20 is duplicate of FWASB02-20.
JH - estimated high value.
JL - estimated low value.
Blanks indicate analyte not reported at method detection limit.

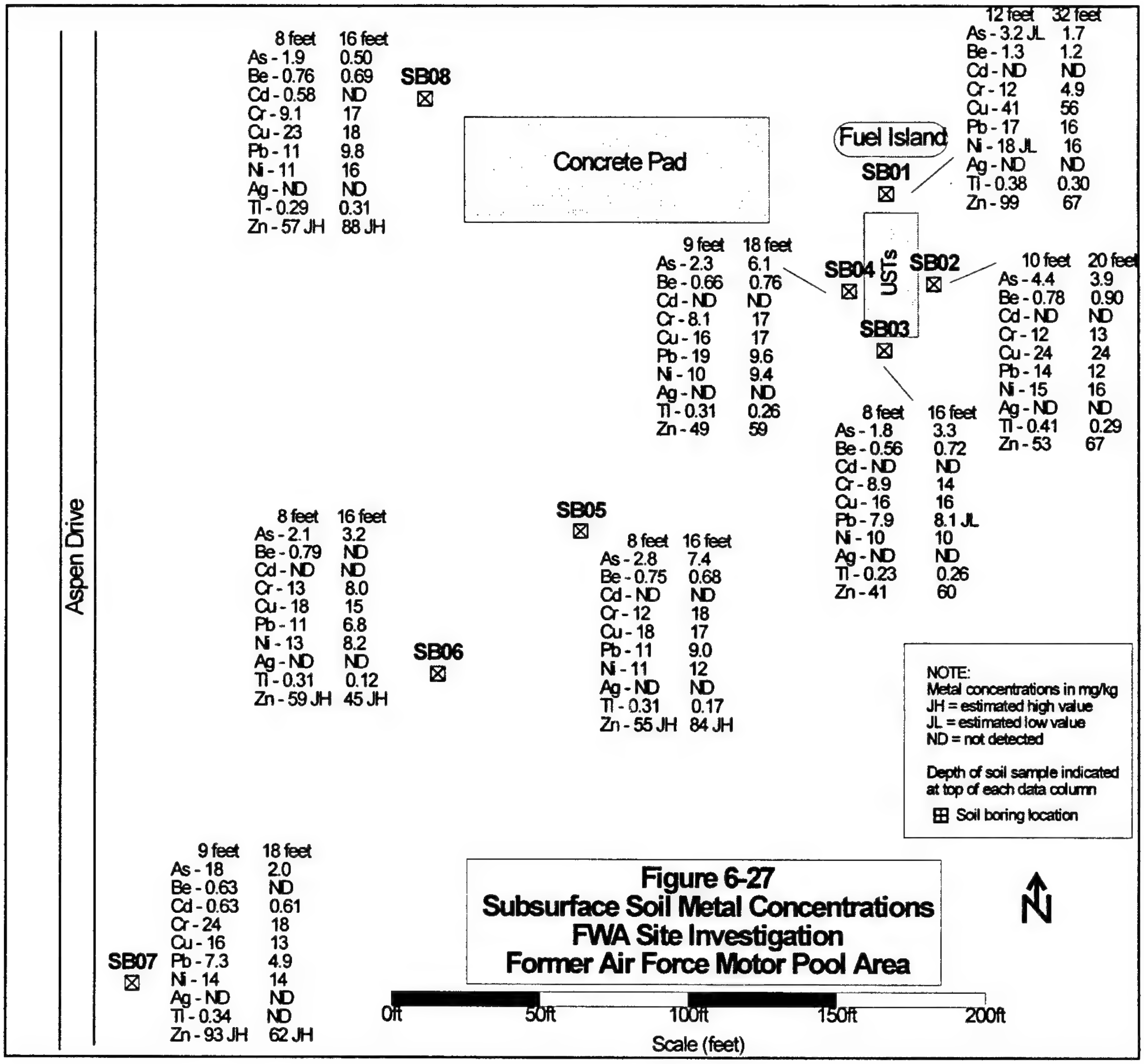


Figure 6-27
Subsurface Soil Metal Concentrations
FWA Site Investigation
Former Air Force Motor Pool Area

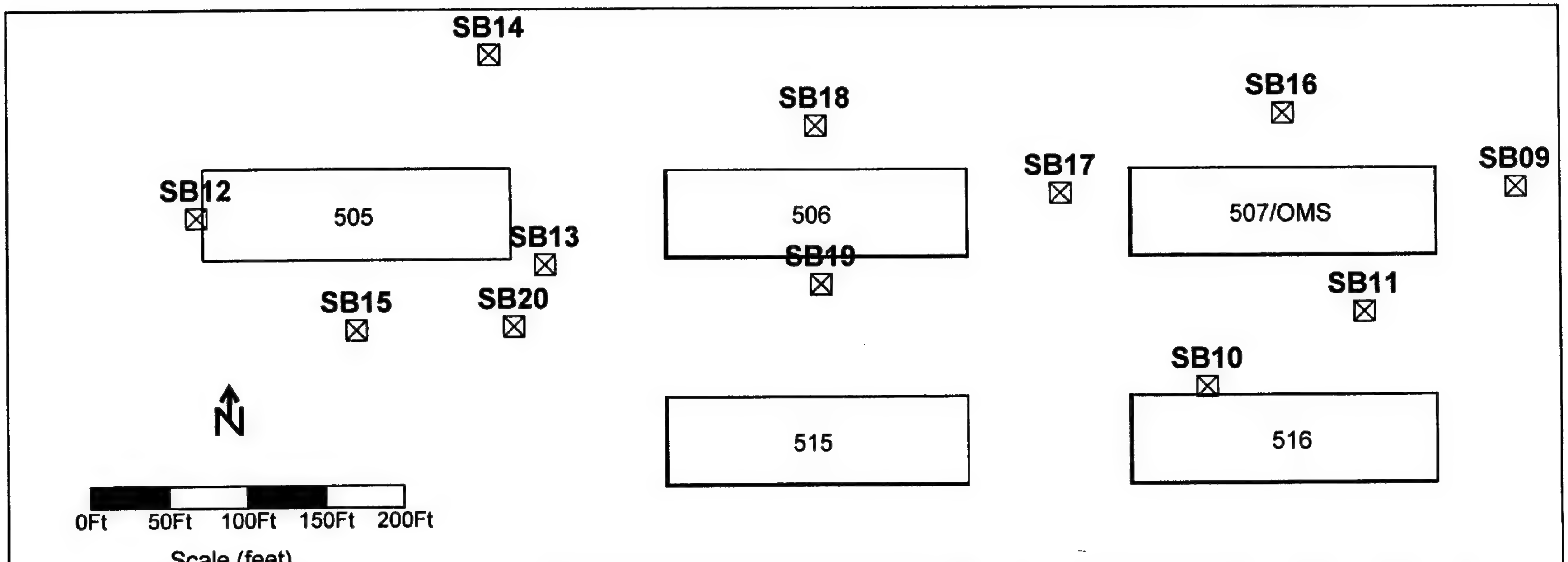


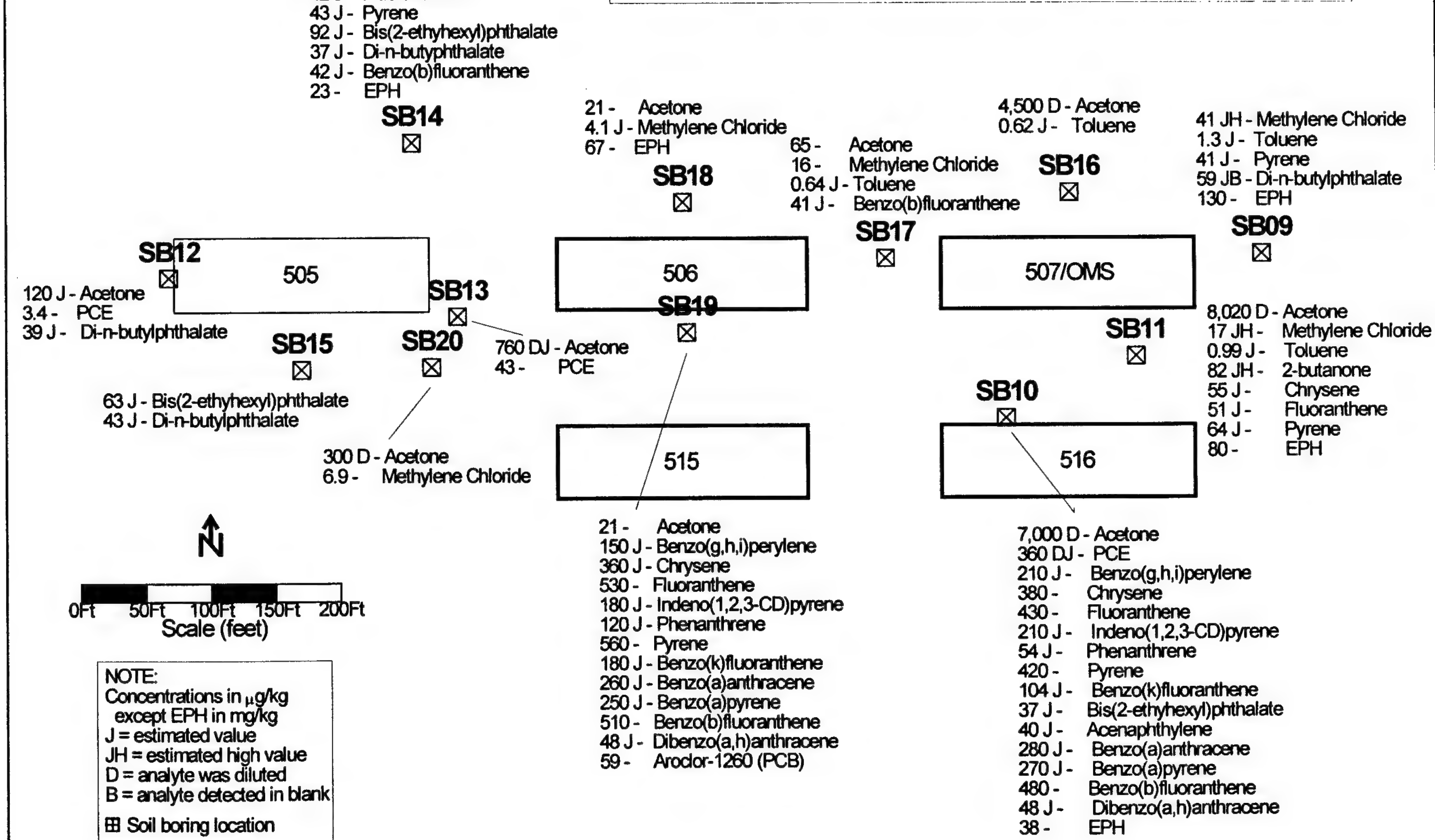
Figure 6-28
FWA Site Investigation
Former Depot Area - Warehouse Buildings 505, 506, and 507/OMS
Soil Boring Locations

Table 6-15
Surface Soil VOC Summary
FWA Site Investigation
Former Depot Area

Sample	2-Butanone	Acetone	M,P-Xylenes	Methylene Chloride	O-Xylene	PCE	Toluene
FWASB09-00				41 JH			1.3 J
FWASB10-00		7000 D				360 D J	
FWASB11-00	82 JH	8020 D		17 JH			0.99 J
FWASB12-00		120 J				10	
FWASB13-00		760 D J				43	
FWASB14-00		33 J		8.6 J		61	
FWASB16-00		4500 D					0.62 J
FWASB17-00		65		16			0.64 J
FWASB18-00		21		4.1 J			
FWASB19-00		21					
FWASB20-00		300 D		6.9			

Note: VOC concentrations in µg/kg.
D - analyte was diluted.
J - estimated value.
JH - estimated high value.
Blanks indicate analyte not reported at method detection limit.

Figure 6-29
Surface Soil Organic Compounds
FWA Site Investigation
Former Depot Area - Warehouse Buildings 505, 506, and 507/OM



benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, and di-n-butylphthalate. Pyrene, fluoranthene, and benzo(b)fluoranthene occur in the highest concentrations. The highest total SVOC concentrations occur at soil borings FWASB10, FWASB14, and FWASB19. No other VOCs were reported in surface soil samples above the method detection limit. Table 6-16 presents all SVOCs reported in surface soil samples from the Former Depot area. Figure 6-29 illustrates the distribution of surface soil SVOCs at the Former Depot area.

6.5.2.1.3 Former Depot Area Surface Soil EPH and VPH Analytical Results

EPHs were reported in surface soils at soil borings FWASB09, FWASB10, FWASB11, FWASB14, and FWASB18 at concentrations ranging from 23 mg/kg to 130 mg/kg. EPHs were not reported in any other surface soil samples above the method detection limit. VPHs were not reported in any surface soil samples collected within the Former Depot area above the method detection limit. Table 6-17 presents a tabular summary of Former Depot area surface soil EPH and VPH concentrations. The EPH and VPH distribution within surface soils are presented in Figure 6-29.

6.5.2.1.4 Former Depot Area Surface Soil Pesticides, Herbicides, and PCB Analytical Results

Pesticides, herbicides, and PCBs were analyzed from surface soil samples FWASB13-00, FWASB17-00, FWASB18-00, and FWASB19-00. No pesticides or herbicides were reported above the method detection limits. However, the PCB compound, Aroclor-1260, was detected at soil boring location FWASB19 at a concentration of 59 µg/kg. The distribution of PCBs within surface soils are presented in Figure 6-29.

6.5.2.1.5 Former Depot Area Surface Soil PP Metals Analytical Results

Metals reported in surface soil samples collected from the Former Depot area include arsenic, beryllium, cadmium, chromium, copper, lead, nickel, silver, thallium, and zinc. All these metals, except for silver, were reported at concentrations equal to or greater than the local background surface soil samples. However, concentrations of metals reported were all within the concentration ranges for those metals reported in the western United States. Antimony, mercury, and selenium were not reported in Former Depot area surface soil samples above the method detection limit. Table 6-18 presents surface soil samples with metal concentrations equal to or greater than local surface soil samples. Figure 6-30 illustrates the distributions of surface soil metals at the Former Depot area. Surface soil samples collected at the Former Depot area with metal concentrations equal to or greater than local background concentrations are illustrated in Figure 6-31.

Table 6-16
Surface Soil SVOC Summary
FWA Site Investigation
Former Depot Area

Analyte	FWASB09-00	FWASB10-00	FWASB11-00	FWASB12-00	FWASB14-00	FWASB15-00	FWASB17-00	FWASB19-00
Acenaphthylene		40 J						
Benzo(a)anthracene		280 J						260 J
Benzo(a)pyrene		270 J						250 J
Benzo(b)fluoranthene		480			42 J		41J	510
Benzo(g,h,i)perylene		210 J						150 J
Benzo(k)fluoranthene		140 J						180 J
Bis(2-ethylhexyl)phthalate		37 J			92 J	63 J		
Chrysene		380	55 J					360 J
Di-n-butylphthalate	59 J B			39 J	37 J	43 J		
Dibenz(a,h)anthracene		48 J						48 J
Fluoranthene		430	51 J		42 J			530
Indeno(1,2,3-cd)pyrene		210 J						180 J
Phenanthrene		54 J						120 J
Pyrene	41 J	420	64 J		43 J			560

Note: SVOC concentrations in µg/kg.
B - analyte was reported in blank sample.
J - estimated value.
Blanks indicate analyte not reported at method detection limit.

Table 6-17 Surface Soil EPH and VPH Summary FWA Site Investigation Former Depot Area		
Sample	**EPH**	**VPH**
FWASB09-00	130	
FWASB10-00	38	
FWASB11-00	80	
FWASB14-00	23	
FWASB18-00	67	

Note: EPH concentrations in mg/kg.
VPH concentrations in µg/kg.
Blanks indicate analyte not reported at method detection limit.

Table 6-18
Surface Soil Samples with Metal Concentrations Greater or Equal to Local Surface Soil Background
FWA Site Investigation
Former Depot Area

Sample	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead, total	Mercury	Nickel	Silver	Zinc
FWASB09-00	3.6		3.9		20	120				190
FWASB10-00				26	20				78	
FWASB11-00										95
FWASB12-00					24					
FWASB13-00								15 J		
FWASB15-00	2.6 JL	1.1						15 J		
FWASB16-00	4 JL									87
FWASB19-00					19					85
FWASB20-00	2.9 JL			22 JH	19			15 J		
FWASB33-00	3.4							16		130 JH
FWASB34-00	3.5									

Note: Metal concentrations in mg/kg.
J - estimated value.
JH - estimated high value.
JL - estimated low value.
Blanks indicate analyte not reported at method detection limit.

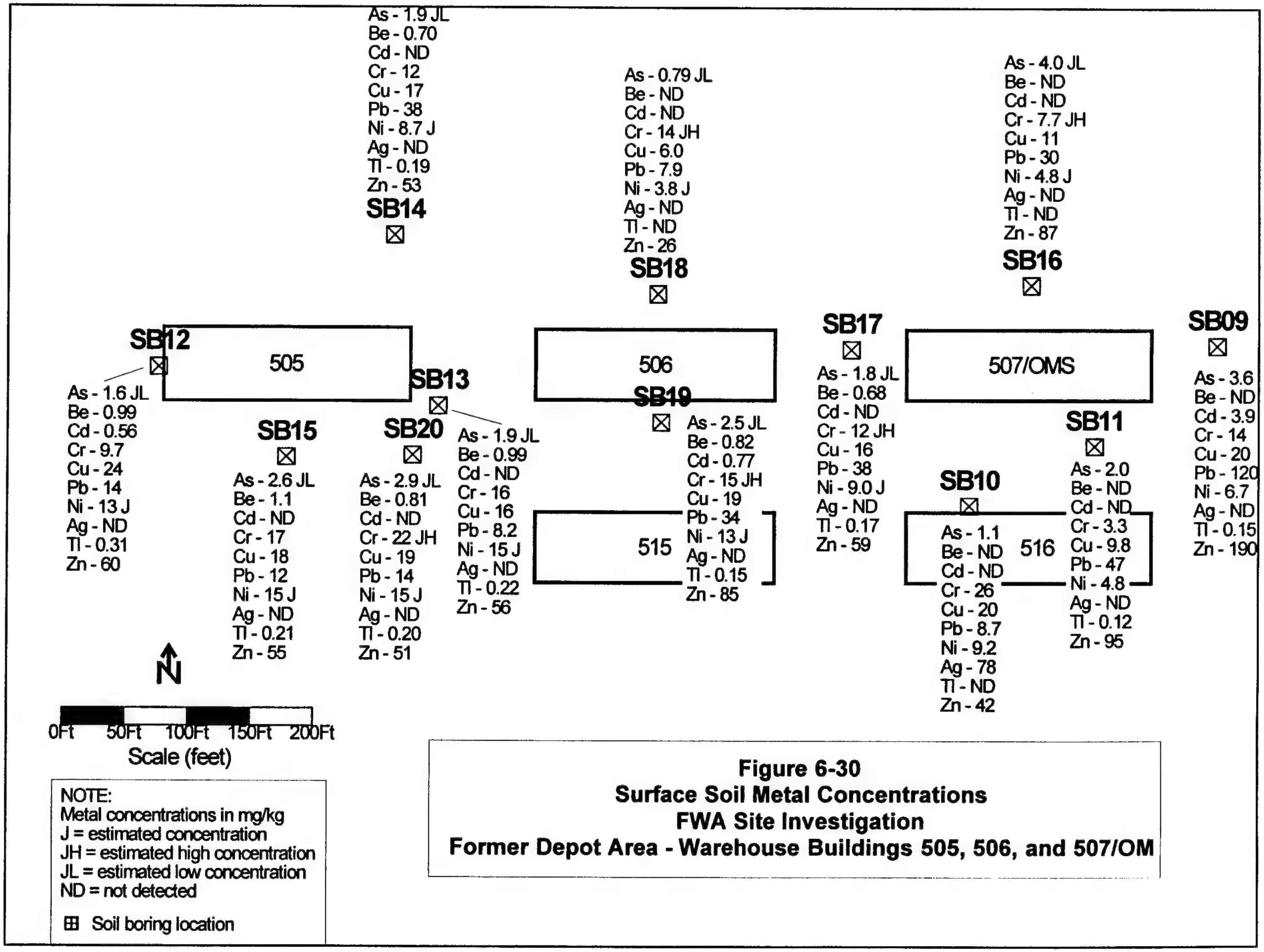


Figure 6-30
Surface Soil Metal Concentrations
FWA Site Investigation
Former Depot Area - Warehouse Buildings 505, 506, and 507/OM

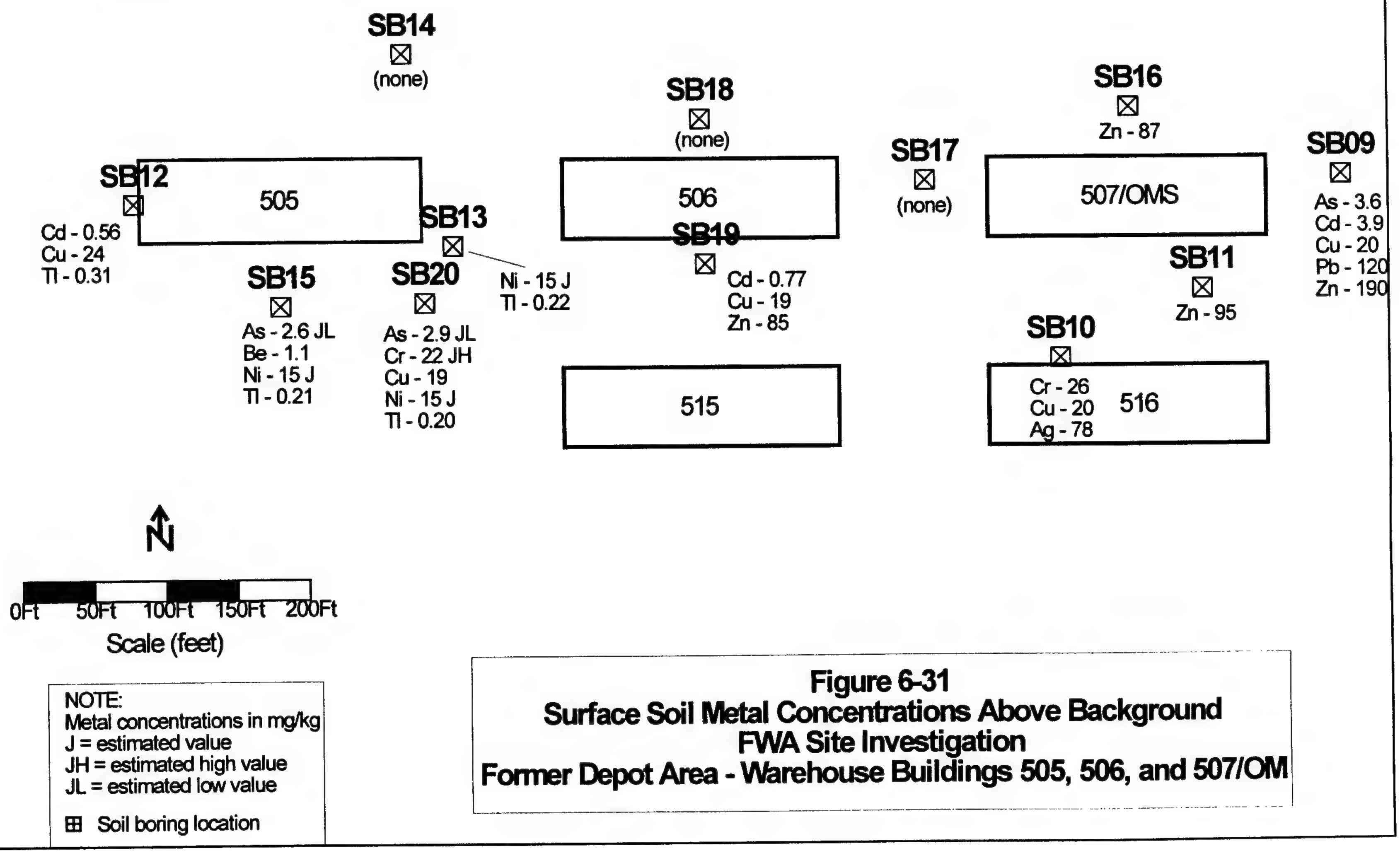


Figure 6-31
Surface Soil Metal Concentrations Above Background
FWA Site Investigation
Former Depot Area - Warehouse Buildings 505, 506, and 507/OM

6.5.2.2 Former Depot Area Subsurface Soil Sample Results

Subsurface soil samples were collected from approximately the middle and bottom of each boring for chemical analysis. A total of 36 subsurface soil samples were collected. Individual samples were obtained from a 2-to-4 ft interval from the soil core.

6.5.2.2.1 Former Depot Area Subsurface VOC Analytical Results

Acetone, methylene chloride, toluene, PCE, TCE, and 2-butanone were reported in subsurface soils at the Former Depot area. Acetone was reported in 18 soil samples, with concentrations ranging from 28 μg/kg to 7,700 μg/kg at all soil boring locations except for FWASB09. Methylene chloride was reported in eight soil samples at six boring locations, FWASB10, FWASB11, FWASB16, FWASB17, FWASB18, and FWASB20 at concentrations ranging from 6.1 μg/kg to 26 μg/kg. Toluene was reported at soil boring FWASB16 at a depth of 6 to 8 ft bgs at a concentration of 0.72 μg/kg. PCE was reported in 10 soil samples from six borings: FWASB10, FWASB12, FWASB13, FWASB14, FWASB15, and FWASB20. PCE was reported within the bottom soil sample from each boring and ranged in concentration from 3.0 μg/kg to 180 μg/kg. The compound 2-butanone was reported at soil borings FWASB09 (18 to 20 ft bgs), FWASB16 (6 to 8 ft bgs), and FWASB18 (6 to 8 ft bgs) at concentrations of 31 μg/kg, 50 μg/kg, and 100 μg/kg, respectively. No other VOCs were reported in subsurface soil samples above the method detection limit. Table 6-19 presents all reported VOCs from Former Depot area subsurface soil samples. Figure 6-32 illustrates the distribution of subsurface soil VOCs at the Former Depot area.

6.5.2.2.2 Former Depot Area Subsurface Soil SVOC Analytical Results

Two SVOCs were reported in subsurface soils at the Former Depot area. Di-n-butylphthalate was reported at boring FWASB12 (18 to 20 ft bgs) at a concentration of 42 μg/kg. Butylbenzylphthalate was reported at a concentration of 40 μg/kg at soil boring FWASB17 at a depth of 6 to 8 ft bgs. No other SVOCs were reported in any Former Depot area subsurface soil samples above the method detection limit. Figure 6-32 illustrates the distribution of subsurface soil SVOCs at the Former Depot area.

6.5.2.2.3 Former Depot Area Subsurface Soil EPH and VPH Analytical Results

EPHs and VPHs were not reported in any subsurface soil samples collected from the Former Depot area above the method detection limit.

6.5.2.2.4 Former Depot Area Subsurface Soil Pesticides, Herbicides, and PCB Analytical Results

Pesticides, herbicides, and PCBs were analyzed from all subsurface soil samples collected at FWASB13, FWASB17, FWASB18, and FWASB19. No pesticides, herbicides, or PCBs were reported above the method detection limits.

Table 6-19 Subsurface Soil VOC Summary FWA Site Investigation Former Depot Area						
Sample	**2-butanone**	**Acetone**	**Methylene Chloride**	**PCE**	**Toluene**	**TCE**
FWASB09-14						
FWASB09-18	31					
FWASB10-09			6.1	23		
FWASB10-18		1300 D		180 D		
FWASB11-09		880 E	16			
FWASB11-18			26			
FWASB12-12		260 J		140		4.2
FWASB12-18		89 J		10		
FWASB13-09		95 J		6.1		
FWASB13-17		2900 D J		35		
FWASB14-08		570 D J		62		
FWASB14-16				21		
FWASB15-08		120 J				
FWASB15-16		29 J		6.7		
FWASB16-06	50	7700 D	15		0.72 J	
FWASB16-12		410 D	12			
FWASB17-06		4500 D				
FWASB17-12		41	12			
FWASB18-06	100	200				
FWASB18-12		54	7.9			
FWASB19-12		28				
FWASB20-08		240				
FWASB20-16		4500 D	7.3	28		
FWASB31-09				2.6 J		
FWASB32-09				15		

Note: VOC concentrations in µg/kg.
FWASB31-09 is duplicate of FWASB10-09.
FWASB32-09 is duplicate of FWASB13-09.
D - analyte was diluted.
J - estimated value.
E - reported concentration above instrument calibration range.
Blanks indicate analyte not reported at method detection limit.

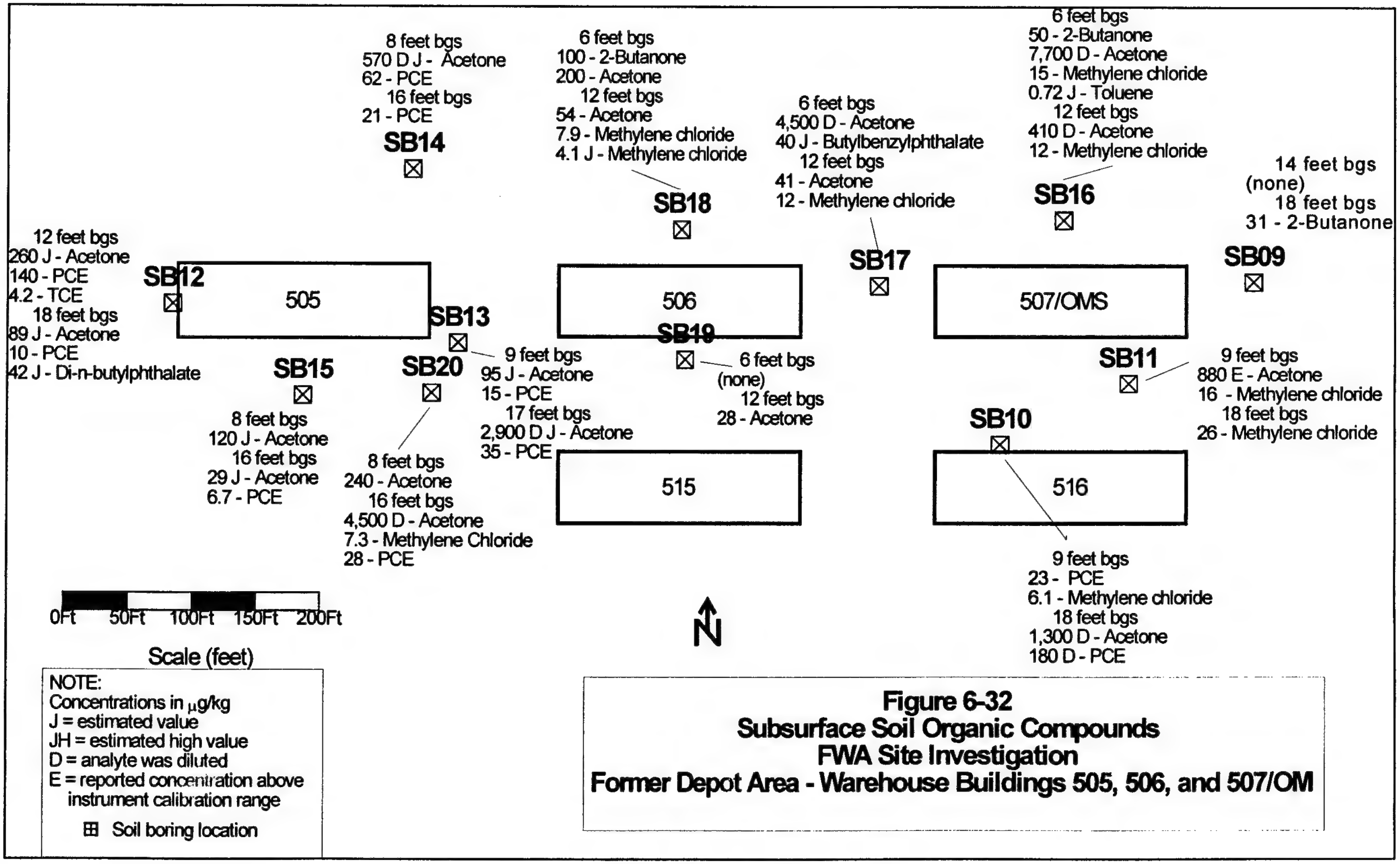


Figure 6-32
Subsurface Soil Organic Compounds
FWA Site Investigation
Former Depot Area - Warehouse Buildings 505, 506, and 507/OM

6.5.2.2.5 Former Depot Area Subsurface Soil PP Metals Analytical Results

Metals reported in subsurface soil samples collected from the Former AF Motor Pool area include arsenic, beryllium, cadmium, chromium, copper, lead, nickel, silver, thallium, and zinc. Concentrations of metals reported were all within the concentration ranges for those metals reported in the western United States. Concentrations of subsurface soil metals are similar to surface soil samples and those collected at the Former AF Motor Pool area. Antimony, mercury, and selenium were not reported in any subsurface soil samples above the method detection limit. A summary of reported subsurface soil metals are presented in Table 6-20. Figure 6-33 illustrates the distribution of subsurface soil metals at the Former Depot area.

Table 6-20
Subsurface Soil Samples with Metal Concentrations Greater or Equal to Method Detection Limit
FWA Site Investigation
Former Depot Area

Sample	Arsenic, total	Beryllium	Cadmium	Chromium	Copper	Lead, total	Nickel	Silver	Thallium, total	Zinc
FWASB09-14	0.83	1.1		9.0	35	18	10		0.36	81
FWASB09-18	1.0	1.2		9.3	43	14	13		0.44	88
FWASB10-09	0.95	0.87		11	26	12	12	1.0	0.46	59
FWASB10-18	2.0	1.0		9.5	39	16	19		0.48	74
FWASB11-09	3.5	1.1	0.74	7.4	35	14	23		0.49	71
FWASB11-18	4.3	1.2		11	45	20	18		0.53	92
FWASB12-12	0.47 JL	1.2	0.69	11	39	15	17 J		0.39	80
FWASB12-18	0.42 JL	1.2	0.74	9.7	36	13	27 J	0.95	0.47	66
FWASB13-09	5.2 JL	0.99		17	22	9.9	16 J		0.43	67
FWASB13-17	0.85 JL	1.2	0.63	18	30	15	170 J		0.34	85
FWASB14-08	1.5 JL	0.56		23	13	7.0	9.8 J			40
FWASB14-16	1.5 JL	1.4	0.73	18	32	11	18 J		0.39	86
FWASB15-08	0.55 JL	1.6		15	35	11	13 J		0.38	80
FWASB15-16	0.52 JL	1.2	0.84	14	41	17	28 J		0.42	83
FWASB16-06	4.1 JL	1.0		19 JH	20	13	17 J		0.23	59
FWASB16-12	2.7 JL	0.72		15 JH	15	8.4	13 J		0.12	53
FWASB17-06	4.2 JL	0.85		15 JH	17	14	16 J		0.27	50
FWASB17-12	2.2 JL	1.1	0.90	12 JH	41	24	32 J		0.37	96
FWASB18-06	4.5 JL	0.91		17 JH	17	14	17 J		0.18	50
FWASB18-12	0.99 JL	1.2	0.81	17 JH	31	13	16 J		0.44	86
FWASB19-06	2.3 JL	0.94		18 JH	22	13	16 J		0.23	60
FWASB19-12				10 JH	35	16	12 J		0.43	57
FWASB20-08	3.9 JL	0.84		33 JH	20	6.8	19 J		0.37	110
FWASB20-16	1.3 JL	1.1		22 JH	30	10	19 J		0.47	98
FWASB31-09	0.64	0.90		10	30	14	10	2.2	0.40	62
FWASB32-09	5.4 JL	1.1		15 J	24	9.1	15		0.35	72

Note: Metal concentrations in mg/kg.
FWASB31-09 is duplicate of FWASB10-09.
FWASB32-09 is duplicate of FWASB13-09.
Blanks indicate analyte not reported at method detection limit.

JH - estimated high value.
JL - estimated low value.
J - estimated value.

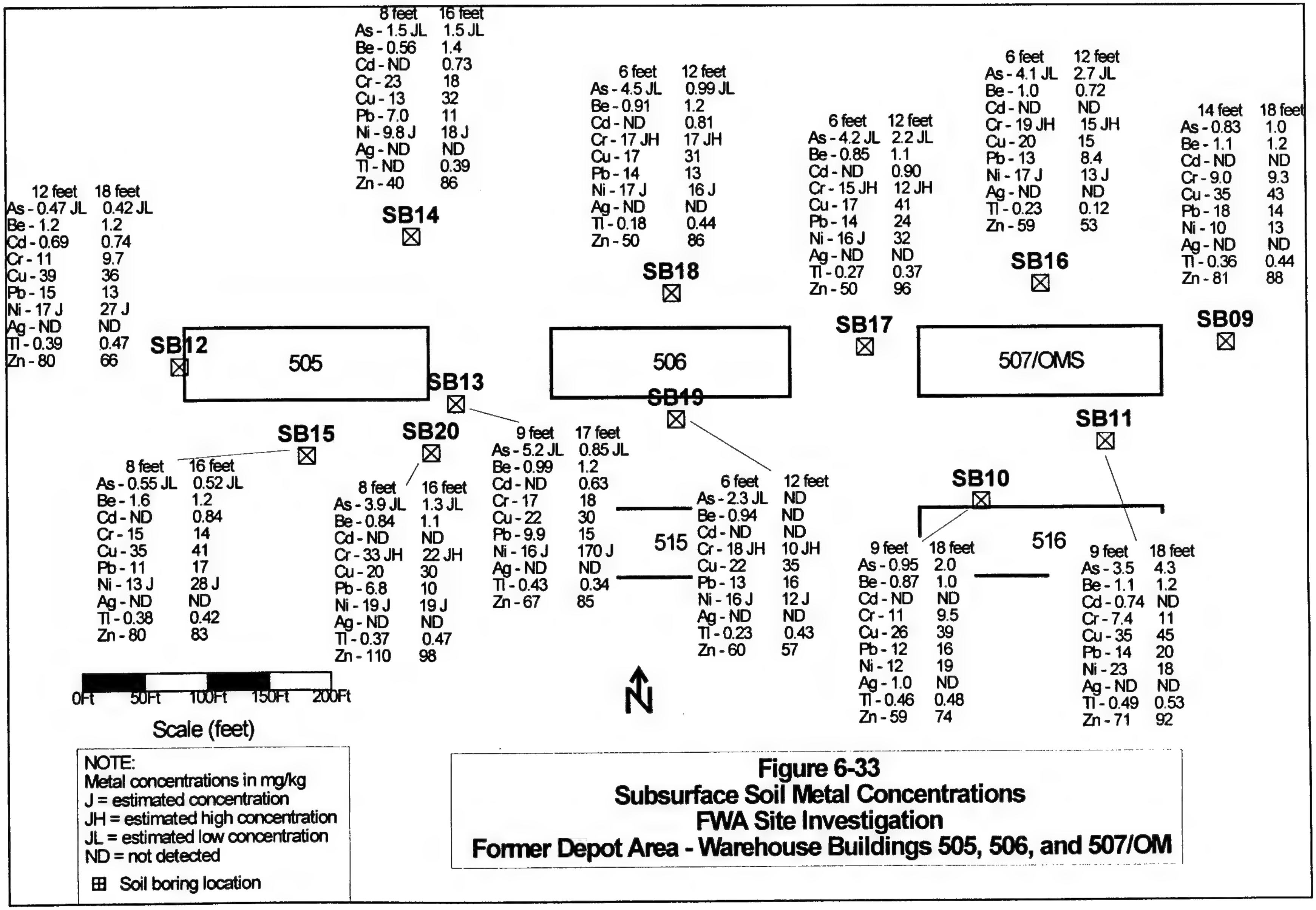


Figure 6-33
Subsurface Soil Metal Concentrations
FWA Site Investigation
Former Depot Area - Warehouse Buildings 505, 506, and 507/OM

6.6 GROUNDWATER SAMPLING RESULTS

Two rounds of groundwater sampling, conducted on November 19 and December 13, 1996, were completed as part of the FWA SI. A total of 14 groundwater samples were obtained from seven FWA SI monitoring wells and piezometers. In addition, one equipment blank, one field blank, two duplicates, and two trip blanks were collected in accordance with the Final SI Work Plan. Organic and inorganic analytical results are presented in Tables 6-21 through 6-2[illegible]. The distribution of reported organic and inorganic groundwater analytes are presented in Figures 6-34 through 6-38 collected from the FWA monitoring wells and piezometers from the first and second sampling rounds, respectively.

6.6.1 Groundwater VOCs

VOCs reported in groundwater included 1,1-dichloroethene, 1,2-dichloroethane, carbon tetrachloride, chloroform, PCE, and TCE. The detection of these compounds was generally consistent for each of the two sampling rounds. PCE was reported most frequently and at the highest concentrations. Groundwater downgradient of the Former Depot area warehouses contained only PCE and TCE, with the highest concentrations occurring at monitoring well FWAMW03. Low concentrations of organic compounds 1,1-dichloroethene, 1,2-dichloroethane, carbon tetrachloride, and PCE were exclusively reported in groundwater from monitoring well FWAMW06 located downgradient of the Former AF Motor Pool area. Chloroform was also detected at monitoring well FWAMW06, however due to its presence in equipment and field blank samples finding it in the monitoring well sample suggests it is likely the result of field contamination. Table 6-21 presents the concentrations of VOCs reported in groundwater at the FWA. The Colorado Primary Drinking Water Regulation Maximum Contaminant Levels (CO MCLs) are also provided in Table 6-21 for comparison. Figures 6-34 and 6-35 present the distribution of groundwater VOCs detected at the FWA equal to or greater than the CO MCLs.

6.6.2 Groundwater SVOCs

Low concentrations of bis(2-ethylhexyl) phthalate, butylbenzylphthalate, and di-n-butylphthalate were reported in groundwater samples from both the Former AF Motor Pool and Former Depot areas. In general, bis(2-ethylhexyl) phthalate was reported in samples collected from the first sampling round, and butylbenzylphthalate and di-n-butylphthalate were reported in the second sampling round. All phthalates, except for bis(2-ethylhexyl) phthalate in sample FWAMW04-02, were reported below the reporting limit for the analytical method and are qualified as estimated. Table 6-22 presents the concentrations of SVOCs reported within groundwater at the FWA. There are no CO MCL standards for the detected FWA groundwater SVOCs.

6.6.3 Groundwater Extractable and Volatile Petroleum Hydrocarbons

Table 6-23 presents EPH and VPH reported in groundwater samples collected from the FWA. These compounds were reported in groundwater downgradient of the Former Depot area warehouses. EPH was only reported in groundwater from piezometer FWAPZ01 at a

Table 6-21
Reported Groundwater VOCs
(Sampling Rounds 11/19/96 and 12/13/96)
FWA Site Investigation

Sample	1,1-Dichloroethene	1,2-Dichloroethane	Carbon Tetrachloride	Chloroform	PCE	TCE
FWAMW03-01					**6400 D**	
FWAMW03-02					**6400 D**	
FWAMW04-01					**100 D**	
FWAMW04-02					**100 D**	
FWAMW06-01		**15**	**2.1**	1.3 **	3.6	
FWAMW06-02	1.3	**7.1 J**	**1.7**			
FWAMW07-01						
FWAMW07-02						
FWAMW08-01					**5900 D**	**170 D**
FWAMW08-02					**5900 D**	
FWAPZ01-01 *						
FWAPZ01-02 *						
FWAPZ04-01						
FWAPZ04-02					**6.2**	
FWAPZ05-01					**340 D**	**47 D**
FWAPZ05-02					**260 D**	**79 D JH**
Maximum Contaminant Level	7.0	NR	0.3	1.3	5	5

Note: * - Background well.
** - Laboratory contaminant.
VOC concentration in μg/l.
FWAMW08 is duplicate of FWAMW03.
D - analyte was diluted.
JH - estimated high value.
J - estimated value.
NR - not reported.
Blanks indicate analyte not reported at method detection limit.
BOLD indicates results exceed the Maximum Contaminant Level.

Table 6-22
Reported Groundwater SVOCs
(Sampling Rounds 11/19/96 and 12/13/96)
FWA Site Investigation

Sample	Bis(2-Ethylhexyl) Phthalate	Butylbenzylphthalate	Di-N-Butylphthalate
FWAMW03-01	1.1 J		
FWAMW03-02		2.3 J	1.1 J
FWAMW04-01			
FWAMW04-02	17 B		
FWAMW06-01			
FWAMW06-02			
FWAMW07-01			
FWAMW07-02		1.2 J	1.3 J
FWAMW08-01			
FWAMW08-02		1.9 J	1.3 J
FWAPZ01-01 *	1.9 J		
FWAPZ01-02 *		1.7 J	
FWAPZ04-01			1.4 J
FWAPZ04-02			
FWAPZ05-01	1.5 J		
FWAPZ05-02			
Maximum Contaminant Level	NR	NR	NR

Note: * - Background Well.
SVOC concentrations in µg/l.
FWAMW08 is duplicate of FWAMW03.
B - analyte was reported in blank.
J - estimated value.
NR - not reported.
Blanks indicate analyte not reported at method detection limit.

Table 6-23 Reported Groundwater EPH and VPH (Sampling Rounds 11/19/96 and 12/13/96) FWA Site Investigation		
Sample	**EPH**	**VPH**
FWAMW03-01		1,900
FWAMW03-02		2,100
FWAMW08-01		2,000
FWAMW08-02		2,100
FWAPZ04-01	1.9	
FWAPZ05-01		120

Note: EPH concentration in mg/l.
VPH concentration in µg/l.
FWAMW08 is duplicate of FWAMW03.
Blanks indicate analyte not reported at method detection limit.

Table 6-24 Reported Groundwater Total Metals (Sampling Rounds 11/19/96 and 12/13/96) FWA Site Investigation						
Sample	**Arsenic**	**Chromium**	**Copper**	**Lead**	**Selenium**	**Zinc**
FWAMW03-01		**0.92 µg/l**		1.2 µg/l		
FWAMW03-02						0.015 mg/l
FWAMW04-01					**36 µg/l**	0.014 mg/l
FWAMW04-02					**30 µg/l**	
FWAMW06-01					**110 µg/l**	
FWAMW06-02			0.034 mg/l	5.5 µg/l	**110 µg/l**	0.080 mg/l
FWAMW07-01			0.035 mg/l	8.0 JL µg/l	**17 µg/l**	0.070 mg/l
FWAMW07-02			0.024 mg/l	5.0 µg/l	**13 µg/l**	0.056 mg/l
FWAMW08-01		**0.92 D mg/l**			**82 µg/l**	
FWAMW08-02		**0.83 mg/l**			**76 µg/l**	0.016 mg/l
FWAPZ01-01 *				3.6 µg/l	**99 µg/l**	0.15 D mg/l
FWAPZ01-02 *			0.012 mg/l		**110 µg/l**	0.028 mg/l
FWAPZ04-01	2.4 µg/l			17 µg/l	**380 µg/l**	0.14 D mg/l
FWAPZ04-02			0.016 mg/l		**290 µg/l**	0.038 mg/l
FWAPZ05-01				1.4 µg/l	**73 µg/l**	0.030 mg/l
FWAPZ05-02					**64 µg/l**	0.022 mg/l
Maximum Contaminant Level	50 µg/l	0.05 mg/l	1.3 mg/l	50 µg/l	10 µg/l	NR

Note: * - Background well.
FWAMW08 is duplicate of FWAMW03.
D - analyte was diluted.
JL - estimated low value.
NR - not reported.
Blanks indicate analyte not reported at method detection limit.
BOLD indicates result exceeds the Maximum Contaminant Level.

Table 6-25 Reported Groundwater Dissolved Metals (Sampling Rounds 11/19/96 and 12/13/96) FWA Site Investigation		
Sample	**Chromium**	**Selenium**
FWAMW03-01	**0.88 D mg/l**	**68 µg/l**
FWAMW03-02	**0.82 mg/l**	**75 µg/l**
FWAMW04-01		**32 µg/l**
FWAMW04-02		**31 µg/l**
FWAMW06-01		**92 µg/l**
FWAMW06-02		**110 µg/l**
FWAMW07-01		**14 µg/l**
FWAMW07-02		**10 µg/l**
FWAMW08-01	**0.88 D mg/l**	**73 µg/l**
FWAMW08-02	**0.82 mg/l**	**80 µg/l**
FWAPZ01-01 *		**100 µg/l**
FWAPZ01-02 *		**100 µg/l**
FWAPZ04-01		**400 µg/l**
FWAPZ04-02		**290 µg/l**
FWAPZ05-01		**68 µg/l**
FWAPZ05-02		**73 µg/l**
Maximum Contaminant Level	0.05 mg/l	10 µg/l

Note: * Background well.
FWAMW08 is duplicate of FWAMW03.
D - analyte was diluted.
Blanks indicate analyte not reported at method detection limit.
BOLD indicates results is equal to or exceeds Maximum Contaminant Level.

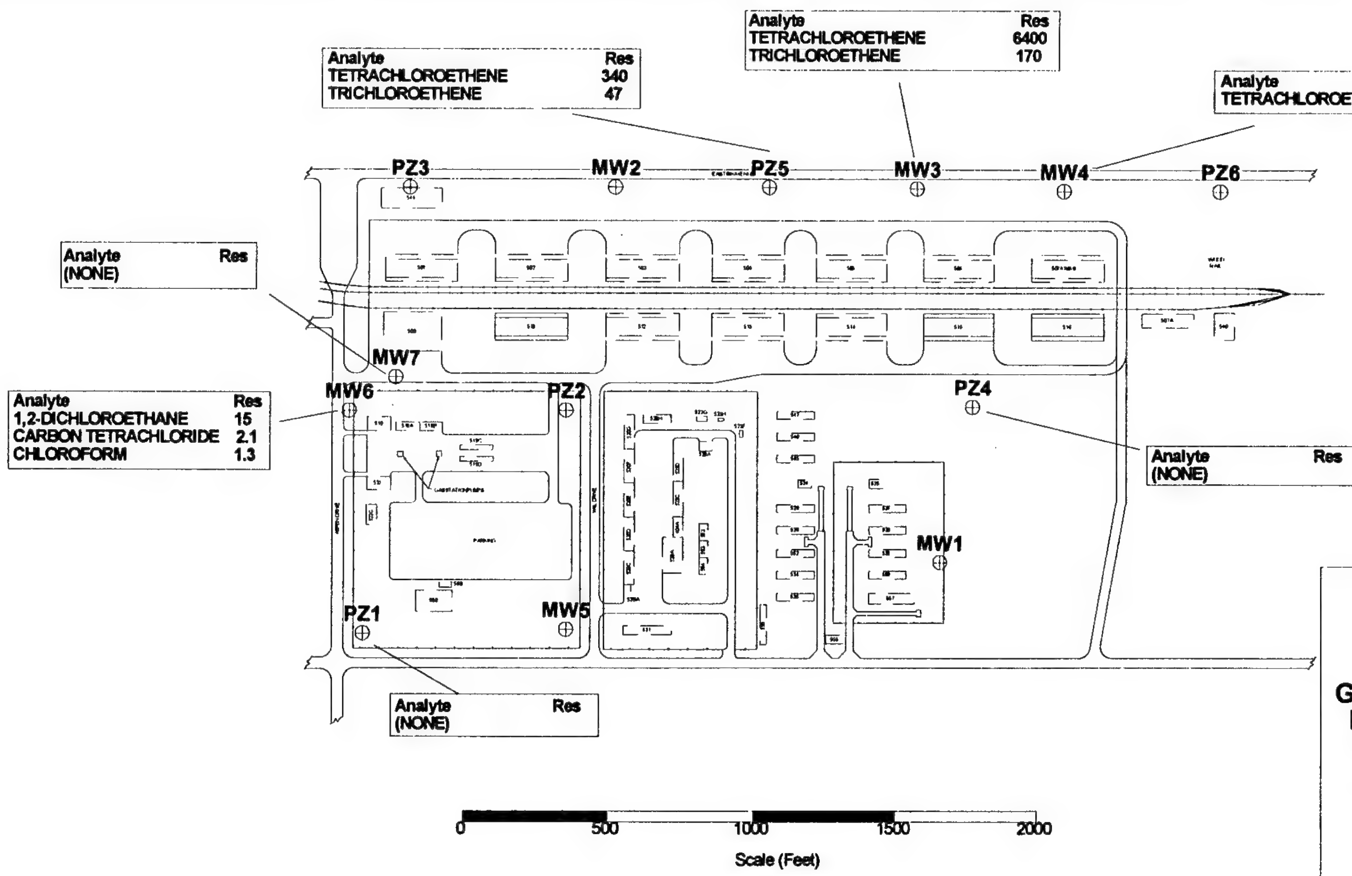


Figure 6-34
FWA Site Investigation
Groundwater Organic Compounds
Equal To Or Greater Than MCLs
First Sampling Round
(Samples Collected 11/19/96)

⊕ Piezometer/Monitoring Well

All concentrations in $\mu g/l$

N

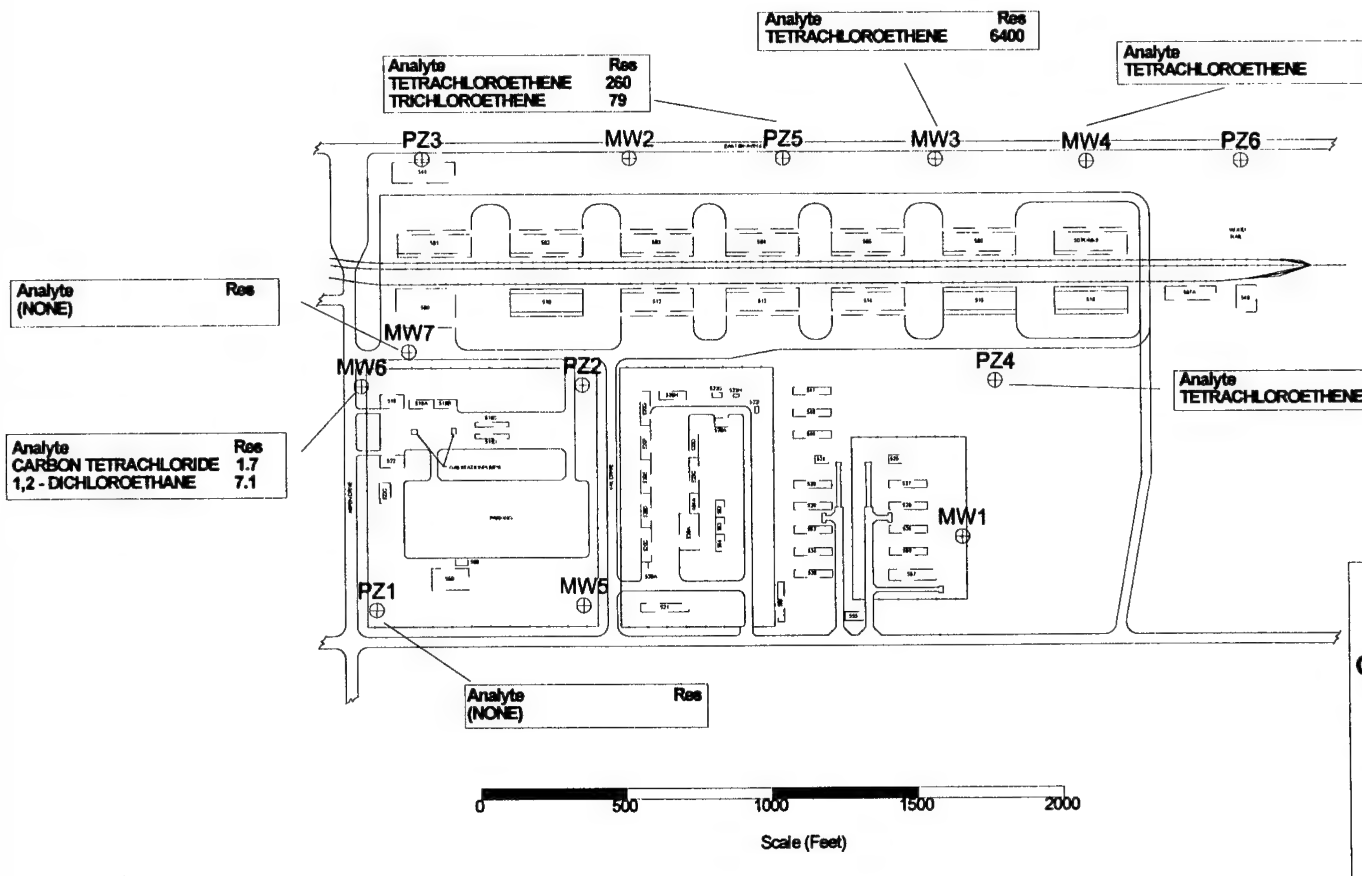


Figure 6-35
FWA Site Investigation
Groundwater Organic Compounds
Equal To Or Greater Than MCLs
Second Sampling Round
(Samples Collected 12/13/96)

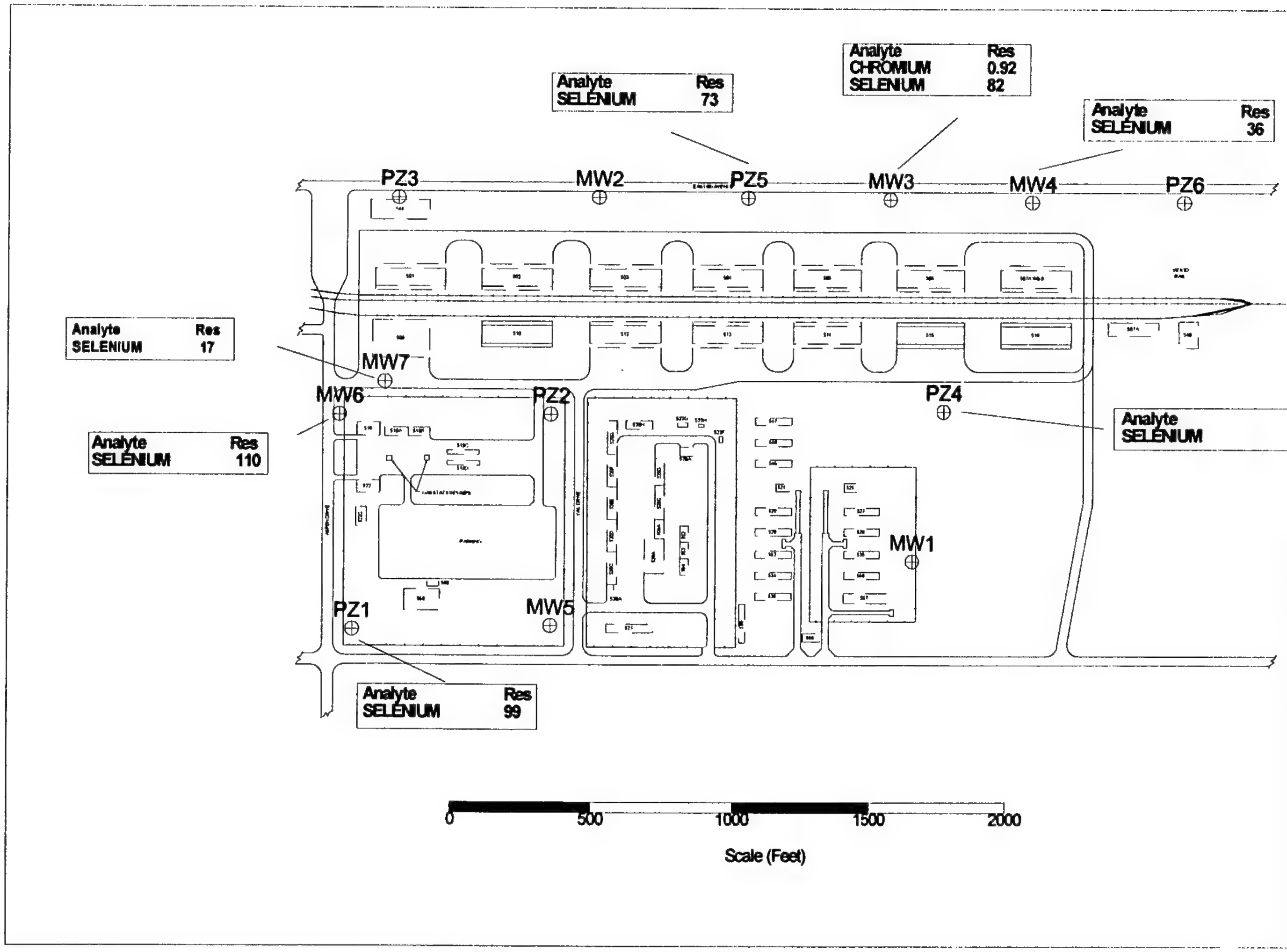


Figure 6-36
FWA Site Investigation
Groundwater Total Metals
Equal To Or Greater Than MCLs
First Sampling Round
(Samples Collected 11/19/96)

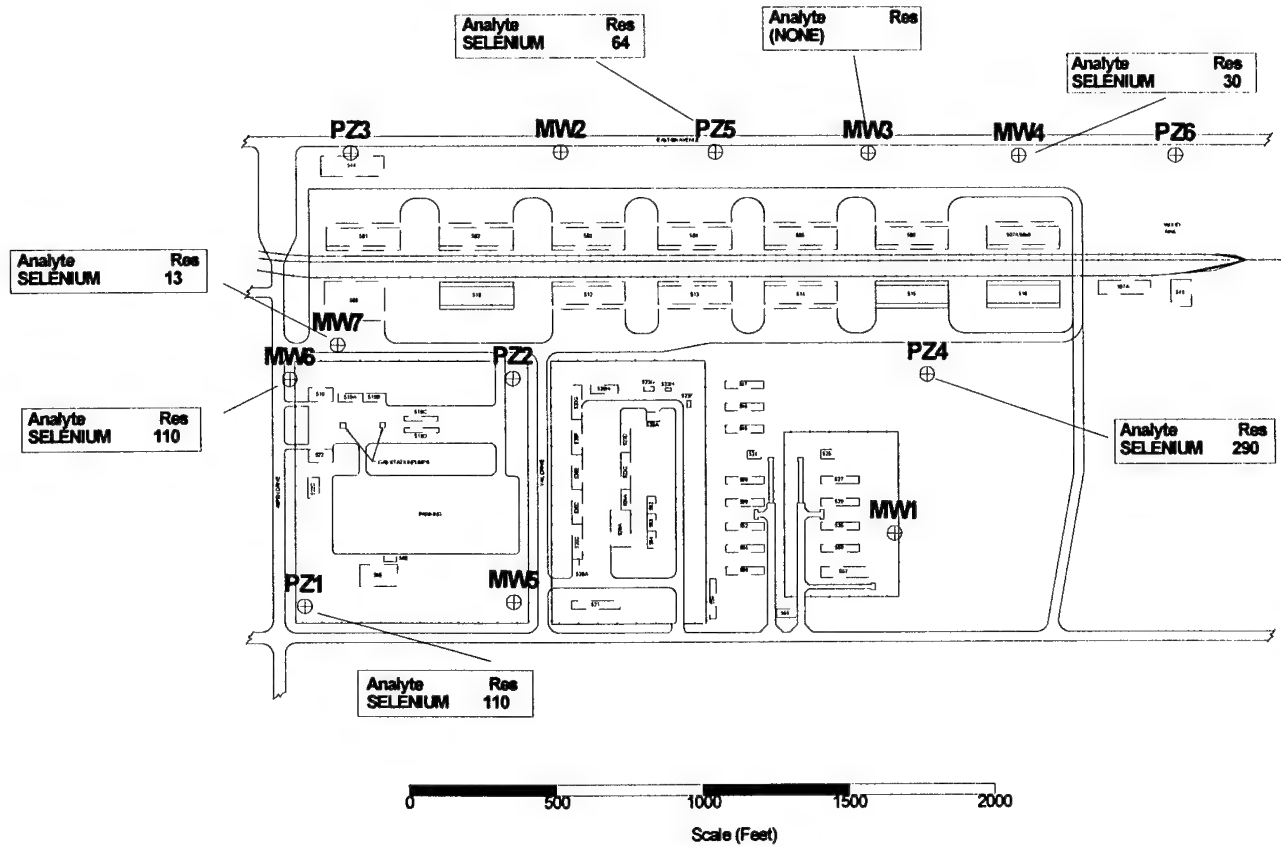


Figure 6-37
FWA Site Investigation
Groundwater Total Metals
Equal To Or Greater Than MCLs
Second Sampling Round
(Samples Collected 12/13/96)

⊕ Piezometer/Monitoring Well

Selenium Concentrations in $\mu g/l$
Chromium Concentrations in mg/l

N

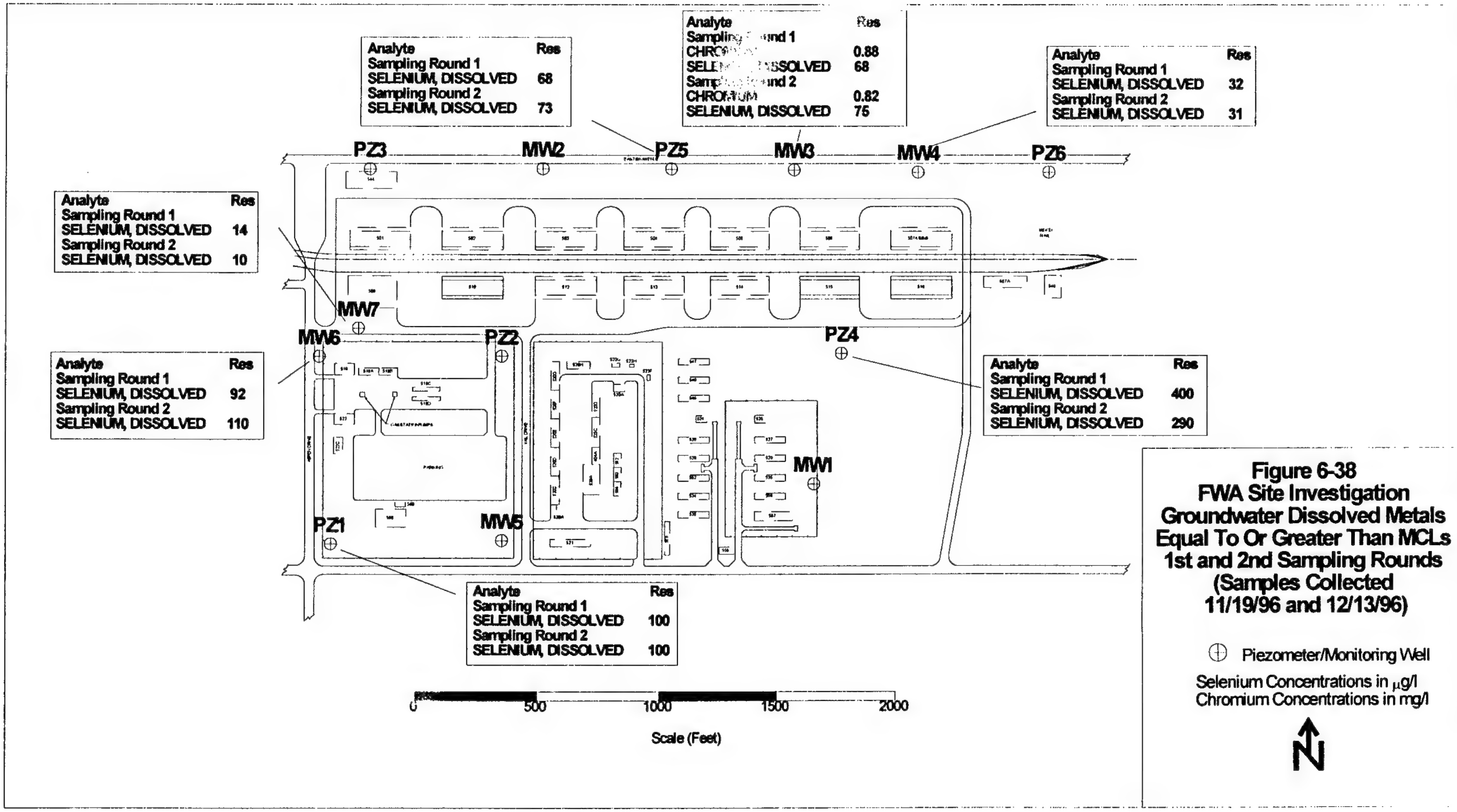


Figure 6-38
FWA Site Investigation
Groundwater Dissolved Metals
Equal To Or Greater Than MCLs
1st and 2nd Sampling Rounds
(Samples Collected
11/19/96 and 12/13/96)

concentration of 1.9 μg/l. VPH was reported at monitoring well FWAMW03 and piezometer FWAPZ01, ranging in concentration from 120 to 2,100 μg/l. VPH was not reported in groundwater from any other sampled FWA well. EPH or VPH was not reported in groundwater samples collected from the Former AF Motor Pool area. Table 6-23 summarizes groundwater concentrations of reported EPH and VPH. There are no CO MCL standards for EPH or VPH.

6.6.4 Groundwater Pesticides, Herbicides, and PCBs

Three groundwater locations, monitoring well FWAMW03 and piezometers FWAPZ01 and FWAPZ04, were sampled and analyzed for pesticides, herbicides, and PCBs. These COPC were not detected in groundwater samples at or above the method detection limits.

6.6.5 Groundwater Metals

Total and dissolved groundwater metals were analyzed for all groundwater samples collected from the FWA. Total metals analyses were reported for arsenic, chromium, copper, lead, selenium, and zinc. Total arsenic was reported once at a concentration of 2.4 μg/l at piezometer FWAPZ04. Total chromium was reported only at monitoring well FWAMW03 at a concentration ranging from 0.83 to 0.92 μg/l over the two sampling rounds. Total copper ranged in concentration from 0.012 to 0.035 mg/l and was reported at FWAMW06, FWAMW07, FWAPZ01, and FWAPZ04. Monitoring wells and piezometers FWAMW03, FWAMW06, FWAMW07, FWAPZ01, FWAPZ04, and FWAPZ05 reported total lead in concentrations ranging from 1.4 to 17 μg/l. Total selenium was the most commonly reported metal; it was reported at all sampled monitoring wells and piezometers and ranged in concentration from 13 to 380 μg/l. Total zinc was also reported at all monitoring wells and piezometers and ranged in concentration from 0.014 to 0.14 mg/l. Table 6-24 presents a summary of reported total metal concentrations in groundwater samples. For comparison, this table includes CO MCLs for metals. Figures 6-36 and 6-37 illustrates groundwater total metals concentrations from both sampling rounds equal to or greater than CO MCLs.

Chromium and selenium were the only reported dissolved metals in groundwater samples collected from the FWA. Chromium, reported only at monitoring well FWAMW03, ranged in concentration from 0.82 to 0.88 mg/l. Dissolved selenium was reported at all monitoring wells and piezometers and ranged in concentration from 10 μg/l to 400 μg/l. Table 6-25 summarizes reported dissolved groundwater metals at the FWA. Figure 6-38 illustrates the distribution of dissolved metal concentrations from both sampling rounds equal to or above CO MCLs.

6.7 QUALITY CONTROL

Quality assurance quality control (QA/QC) samples were collected and analyzed as part of the FWA SI as a check on field sampling. QA/QC samples consisted of equipment blanks, field blanks, trip blanks, and duplicate samples. A total of six equipment blanks, two field blanks, and two trip blanks were collected and analyzed. Duplicate soil and groundwater samples, presented in previous sections, were collected and sent blind to the analytical laboratory. Table 6-26 presents all detected organic compounds and inorganic analytes detected in equipment blanks, field blanks, and trip blank samples.

6.7.1 Equipment Blanks

Equipment rinsate blanks were obtained from soil and groundwater sampling equipment. Equipment blank samples EB1-311096 through EB5-081196 were obtained from soil sampling equipment and consisted of HPLC-grade water used in decontaminating field equipment. Sample EB6-121296 consisted of HPLC-grade water pumped through a decontaminated groundwater sampling pump and associated tubing. All equipment blank samples were analyzed for VOCs, SVOCs, TPH, EPH, PPM, pesticides, herbicides, and PCBs. Equipment blank samples collected during soil sampling were analyzed by EPA SW-846 Method 8240. Volatile analysis of the groundwater equipment blank sample was analyzed using EPA SW-846 Method 8010A.

Acetone, chloroform, and 4-chloro-3-methylphenol were reported in equipment blank samples collected from soil sampling equipment. Acetone was reported in one sample (i.e., EB4-071196) at a concentration of 170 µg/l. Low levels of chloroform were reported in all samples, except EB6-121296, at a maximum concentration of 7.0 ug/l. The compound 4-chloro-3-methylphenol was reported in two samples (i.e., EB4-071196 and EB5-081196) at a maximum estimated concentration of 2.2 µg/l. No inorganic analytes were reported in equipment blanks obtained from soil sampling equipment.

All organic compounds detected in equipment blanks are considered field contaminants due to the very low concentrations detected as well as their absence in soil and trip blank samples. Acetone and methylene chloride, detected in both the equipment blanks and soil samples, may have resulted from the coelution with isopropanol and/or as a minor contaminant in tap water. Isopropanol and tap water were used in the decontamination of sampling equipment.

Acetone concentrations in soil samples ten times greater than 170 µg/l (i.e., 1,700 µg/l) are conservatively assumed to be real and not the result of acetone contamination. The field blank tap water sample contained chloroform.

No organic compounds or inorganic analytes were reported above method detection limits in the equipment blank collected from the decontaminated groundwater sampling equipment.

Table 6-26
Quality Assurance/Quality Control Sample Results
FWA Site Investigation
Buckley ANG Base

Sample	Acetone	Chloroform	1,1,1-Trichloroethane	Methylene Chloride	Dibromo-Chloromethane	Bromodi-Chloromethane	4-Chloro-3-Methylphenol	Lead, dissolved	Lead, total
EB1-311096		5.7							
EB2-041196		4.2							
EB3-051196		5.9							
EB4-071196	170	4.0					2.2 J		
EB5-081196		7.0					1.1 J		
EB6-121296									
FB1-051196									
FB2-121296		15			2.2	5.3		15	3.0
TB1-191196			1.1						
TB2-131296			1.2	5.6					

Note: All concentrations in µg/l.
J - estimated value.
Blanks indicate analyte not reported at method detection limit.

6.7.2 Field Blanks

A field blank is defined as water poured into a sample container at the site, handled like a sample, and transported to the laboratory for analysis. Two field blank samples, FB1-051196 and FB2-121296, were obtained during the FWA SI. Field blanks were analyzed for halogenated VOCs, SVOCs, TPH, EPH, PPM, pesticides, herbicides, and PCBs. Field blank FB1-051196 consisted of HPLC grade water used in the final decontamination rinse of soil sampling equipment. Field blank FB2-121296 consisted of potable tap water from an FWA fire hydrant used for steam cleaning and rinsing of sampling equipment. No organic compounds or inorganic analytes were reported above method detection limits in the HPLC water field blank sample.

The potable tap water field blank sample was collected from a fire hydrant supplied by the Base potable water system. Results of this field blank sample reported low concentrations of bromodichloromethane, chloroform, dibromochloromethane, and dissolved and total lead. It is assumed that the organic compounds are not associated with laboratory contaminants since these compound were not detected in trip blank samples. Low levels of lead are common in potable water systems and the presence of lead is assumed to be real.

6.7.3 Trip Blanks

Two trip blank samples were analyzed during the FWA SI. A trip blank is defined as a sample bottle filled by the laboratory with analyte-free laboratory reagent water, transported to the site, handled like a sample but not opened, and returned to the laboratory for analysis. One trip blank was included with every shipping cooler containing VOC water samples. One trip blank was analyzed for each groundwater sampling round; trip blank TB1-191196 was analyzed with samples from the first sampling round and trip blank TB2-131296 was analyzed with samples from the second sampling round. Trip blanks were not analyzed for soil samples. Both trip blanks were analyzed for halogenated VOCs.

Two VOCs were reported at low concentrations in trip blank samples. Trip blank TB1-191196 reported 1,1,1-trichloroethane at a concentration of 1.1 µg/l. Trip blank TB2-131296 reported 1,1,1-trichloroethane and methylene chloride at concentrations of 1.2 µg/l and 5.6 µg/l, respectively. These organic compounds are assumed to be laboratory contaminants.

6.7.5 Data Evaluation

A data evaluation of the analytical data was conducted. Appendix H contains the laboratory data package summary sheets for each Sample Delivery Group (SDG). This appendix also contains the data evaluation summary of each SDG. The data evaluation did not include an evaluation of calibrations, GC/MS instrument tuning, and interval standards. The data evaluation resulted in additional and/or revised data qualifiers and were incorporated into the data results presented in Appendix I. These qualifiers include estimated high (JH), estimated low (JL), and reject (R).

The data evaluation determined all SDG data packages were complete and holding times were met. Proper corrective actions were performed by the laboratory when surrogate recoveries were outside the QC limit range. All ND results for Dinoseb were rejected when laboratory control samples were outside control limits. Poor precision was observed for acetone which was attributed to coelution with isopropanol.

A summary of all data qualifiers are provided below.

ND - compound or analyte not detected above a reported method detection limit.
U - non-detected compound.
D - analyte was diluted to bring within instrument calibration or to remove matrix interferences.
J - estimated value detected below reported method detection limit.
B - analyte was detected in laboratory method blank.
JL - analyte or compound detected below method detection limit - low value estimate.
JH - analyte or compound detected below method detection limit - high value estimate.
R - reject.

6.8 COMPARISON OF FWA SI AND PHASE I/II EA OF THE USCWTP FINDINGS

The groundwater results from the Phase I/II EA at the City of Aurora USCWTP, located directly to the north and downgradient of the FWA, were the primary impetus for conducting the FWA SI. VOCs, pesticides, herbicides, and metals were detected in shallow groundwater at the USCWTP. It is believed that at least some of these contaminants originate from the FWA. Locations of USCWTP monitoring wells in relation to the FWA are presented in Figure 1-1. This section compares groundwater results of the Phase I/II EA of the USCWTP and the FWA SI.

A comparison of groundwater contaminants detected at the USCWTP and the FWA is presented in Table 6-27. Groundwater contaminants detected at both the USCWTP and the FWA include PCE, TCE, lead, copper, and zinc. Both PCE and TCE were only detected at USCWTP monitoring well MW-1, located directly downgradient of the Former Depot area where the maximum concentrations of these compounds were detected in groundwater at the FWA. Low-level concentrations of VOCs, pesticides, herbicides, arsenic, barium, mercury, and copper were detected in USCWTP, but not in FWA groundwater. Groundwater contaminants detected at the FWA, but not at the USCWTP property, include 1,1-dichloroethene, 1,2-dichloroethene, carbon tetrachloride, chloroform, chromium, and selenium.

The presence of both PCE and TCE within groundwater at the Former Depot area and USCWTP indicate these compounds are originating from the FWA.

Table 6-27
Comparison of USCWTP Phase I/II EA And FWA SI Groundwater Compounds

Analyte (units)	Upper Sand Creek Water Treatment Plant			Former Warehouse Area	
	MW-1	MW-2	MW-3	Former Depot Area	Former AF Motor Pool Area
VOCs (µg/l)					
1,1-Dichloroethene					1.3
1,2-Dichloroethene					15
PCE	410			6400 D	3.6
Methylene Chloride		2			
Acetone		13			
Carbon Disulfide		1			
Carbon Tetrachloride					2.1
Chloroform					1.3
2-Butanone	41	11			
TCE	2			170 D	
Toluene	4	1	1		
Ethyl Benzene	6	1	1		
Total Xylenes	31	5	3		
Substituted Benzene	144	19	7		
TRPH	0.5				
Herbicides (µg/l)					
2,4,-D			719		
Dinoseb			14.5		
Pesticides (µg/l)					
Aldrin			0.03		
Heptachlor Epoxide	0.07	0.12	0.12		
Metals (mg/l)					
Silver		0.05			
Arsenic			0.024		
Barium	0.44	0.34	4.9		
Cadmium					
Chromium				0.92 D	
Lead	0.009	0.0093	0.062	0.0014	0.008
Selenium				0.082	0.110
Mercury			0.0005		
Copper	0.02	0.045	0.27		0.035
Zinc	0.11	0.12	0.74	0.03	0.08

Note: Maximum FWA groundwater COPC are reported.
The Phase I/II EA report does not indicate that groundwater metals samples were filtered.
Blanks indicate analyte not detected at or above method detection limit.
D - analyte was diluted to bring within instrument calibration or to remove matrix interferences.

6.9 DATA GAPS

The FWA SI has determined that contaminant compounds detected in groundwater at the USCWTP are present at the FWA. Additional investigation of the FWA is necessary to further define the types and extent of soil and groundwater contaminants identified by this SI. The following data gaps are based on that need.

6.9.1 Extent of Chemical Constituents Within Soils

The extent of chemical constituents within surface and subsurface soils has not been fully defined at the Former AF Motor Pool and Former Depot areas.

Former AF Motor Pool Area:

- SI soil borings did not fully confirm the lateral extent of potential soils containing chemical constituents as identified by the soil gas survey. Soil gas analyses reported elevated levels of VOCs within soil located along the western and southeastern boundary of the Former AF Motor Pool area where soil borings were not drilled and sampled.

- The vertical extent of chemical constituents within subsurface soils was not confirmed by the SI. Significant concentrations of VOCs, SVOCs, VPHs, and EPHs were detected at the bottom of soil boring FWASB05, located near the center of the Former AF Motor Pool area.

Former Depot Area:

- SI soil borings did not fully characterize the lateral extent of soils containing chemical constituents as identified by the soil gas survey. Soil borings were not drilled and sampled to define the extent of VOCs within soils around and to the north of Former Warehouse 505. VOC-impacted soil may also be present at other former warehouses that existed at the Former Depot area.

- The vertical extent of chemical constituents within subsurface soil was not determined by the SI. Significant concentrations of VOCs at the bottom of soil borings FWASB10, FWASB12, FWASB13, FWASB14, FWASB15, and FWASB20.

6.9.2 Extent of Chemical Constituents Within Groundwater

The complete extent of groundwater containing chemical constituents within the surficial aquifer has not been fully defined at the FWA. PCE, TCE, chromium, and selenium have been reported in groundwater at concentrations equal to or greater than the CO MCLs. The presence of PCE and TCE in groundwater of the USCWTP property, located directly downgradient of the Former Depot area, suggests that these compounds within groundwater are migrating northward from the

FWA. Selenium concentrations in groundwater may be natural within the surficial aquifer since the highest selenium concentrations were detected in background monitoring wells.

- An area of groundwater containing elevated levels of selenium exists at the Former AF Motor Pool area and at background locations. Further investigation of selenium concentrations are needed to determine if observed groundwater concentrations are naturally occurring or the result of human impacts at the FWA.

- Groundwater containing elevated levels PCE, TCE, chromium, and selenium is reported downgradient of the Former Depot area. The horizontal and vertical extent of these chemical constituents within groundwater have not been determined.

- Background surface soil and groundwater samples contained very low concentrations of organic chemical constituents. These compounds, acetone, xylenes, methylene chloride, benzoic acid, and phthalates, are attributed to laboratory or field contamination. However, TCE was reported in groundwater at a concentration slightly above the CO MCL at background well FWAPZ04. The presence of TCE suggests that potential source areas may be adjacent and/or upgradient of this background well, requiring further investigation.

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7.0 SUMMARY AND CONCLUSIONS

This section summarizes findings of the FWA SI. Specifically, the site geology and hydrogeology are summarized, conclusions of the geophysical survey are presented, and the types of chemical constituents detected in soil and groundwater are discussed.

7.1 GEOLOGY AND HYDROGEOLOGY OF THE FORMER WAREHOUSE AREA

The surficial geology of the FWA consists of eolian and alluvial deposits that lie directly atop the erosional surface of the Denver Formation. The eolian deposits consist of contiguous thick sequences of unconsolidated brown clays and silts, with traces of very fine sand. Non-contiguous lenses of alluvial clayey sand, sandy clay, and sandy silts of up to 2.5 ft in thickness were found to occur infrequently. Two contiguous lenses of coarse-grained alluvial sands were observed along the northern boundary and in the southwestern portion of the FWA.

The Denver Formation in the vicinity of the FWA consists of variably consolidated interbedded shale, claystone, siltstone, and sandstones. This sandy siltstone surface of the Denver Formation was encountered at two locations across the FWA at depths of 14 and 28 ft bgs.

Groundwater within the eolian and alluvial deposits above the Denver Formation is referred to as the surficial aquifer. Groundwater primarily occurs within lenses of alluvial material within a matrix of hydraulically tight eolian silts and clays. Groundwater was absent where silts and clays were present or where bedrock of the Denver Formation was encountered. The surficial aquifer is locally unconfined to semi-confined. A slight decline in groundwater levels was observed during the course of the SI.

The flow of groundwater within the surficial aquifer at the FWA generally follows the northerly sloping surface topography. Groundwater flow is toward the northwest on the western portion of the FWA. Flow is more westerly in the southwestern area of the FWA and is toward the northeast on the eastern portion. A low groundwater gradient exists at the FWA, ranging from 0.022 to 0.017. A groundwater divide appears to exist within the surficial aquifer extending from monitoring well FWAMW03 southwest to FWAPZ02 and southward.

The hydraulic conductivity of the surficial aquifer, based on aquifer slug testing, varies from 4.93×10^{-6} ft/sec (1.50×10^{-4} cm/sec) to 8.79×10^{-7} ft/sec (2.68×10^{-5} cm/sec). The hydraulic conductivity geometric mean calculated for the FWA surficial aquifer is 1.17×10^{-6} ft/sec (3.57×10^{-5} cm/sec). The horizontal velocity of groundwater within the surficial aquifer varies from 0.73 to 4.06 ft/yr.

7.2 CHEMICALS OF POTENTIAL CONCERN

Surface soil, subsurface soil, and groundwater media were collected and analyzed as part of the FWA SI. This section summarizes the occurrence and distribution of COPC detected in soils and groundwater at the Former AF Motor Pool and Former Depot areas of the FWA. Tables 7-1 through 7-4 present the maximum concentration of all COPC detected in the sampled media and CO MCLs for appropriate compounds.

7.2.1 Soil and Groundwater Background Occurrence COPC

Low concentrations of EPHs and xylenes were reported in the background surface soil sample location FWASB21. Metals reported in background soil samples include arsenic, beryllium, cadmium, chromium, copper, lead, nickel, silver, thallium, and zinc. The concentration of reported metals are all within the range of reported background metal concentrations of the western United States. Pesticides, herbicides, PCBs, antimony, mercury, and selenium were not reported in background soils above method detection limits.

Local background groundwater samples for the FWA were collected from piezometers FWAPZ01 and FWAPZ04 located upgradient of the Former AF Motor Pool and Former Depot areas, respectively. TCE was detected once in piezometer FWAPZ04 at a concentration of 6.2 μg/l, slightly greater than CO MCL of 5.0 μg/l indicating that this well is downgradient of a contaminant source(s). Background groundwater metals detected included arsenic, copper, lead, selenium, and zinc. Total and dissolved selenium were detected, ranging from 100 μg/l to 400 μg/l, respectively, exceeding the CO MCL of 10 μg/l.

<u>Conclusions:</u>

Background surface soil sample location FWASB22 and groundwater sampling location FWAPZ01 are representative of background organic and inorganic compounds. The presence of EPHs and xylenes at soil sample location FWASB21 and TCE at piezometer FWAPZ04 indicate these locations are not representative of background conditions. Total and dissolved selenium groundwater concentrations exceed the CO MCL.

7.2.2 Former AF Motor Pool Area

Results of a geophysical study, utilizing magnetic and EM sensing equipment, showed numerous magnetic anomalies within the Former AF Motor Pool area. Many of the anomalies are attributed to cultural features and buried conductive objects within the area where the USTs were located. Several unexplained EM anomalies are located in the southern portion of the site and are interpreted to be relatively shallow conductive objects (e.g., demolition debris and underground utilities).

Table 7-1
Summary of Maximum Reported Volatile Organic Compound Concentrations
Former Warehouse Area Site Investigation

Compound	Former AF Motor Pool Area				Former Depot Area				Background		MCL[1]
	Soil Gas (µg/l air)	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Groundwater (µg/l)	Soil Gas (µg/l air)	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Groundwater (µg/l)	Surface Soil (µg/kg)	Groundwater (µg/l)	Groundwater (µg/l)
VOCs											
1,1-Dichloroethene				1.3							7.0
1,2-Dichloroethene				15							NR
1,2-Dichlorobenzene	2.0										
1,3-Dichlorobenzene	3.0										
1,4-Dichlorobenzene	3.0										
1,1,2-Trichloroethane	3.0										
4-Methyl-2-Pentanone	31										
2-Butanone			270 D			82	100				
2-Hexanone	4.4										
cis-1,2-Dichloroethene					62						
Acetone	95	7000 D	3700 D		120	8020 D	7700 D		13		NR
Benzene	13				1.0						
Carbon Tetrachloride				**2.1**							0.3
Chlorobenzene	1.0										
Chloroform				**1.3** *							1.3
Ethylbenzene	26		330 D JH		13						
m,p-Xylenes	5.0	0.98 J	1400 D JH		9.0				0.82 J		
Methylene Chloride		23	33			41 JH	26		9.6		
o-Xylene	2.0	1.4	58 D JH		4.0				0.79 J		
PCE	160			3.6	2100	360 D J	180 D	**6400** D			5
Toluene	1.0	0.61 J				1.3 J	0.72 J				
TCE	4.0				86		4.2	**170** D		**6.2**	5

Note: [1] - Maximum Contaminant Level - Colorado Primary Drinking Water Regulations, Code of Colorado Regulations, Title 5, Chapter 1003, September 30, 1994. Updated November 30, 1995 (6 CCR 1007-3, Part 264 Subpart F 264.94).
* - laboratory contaminant.
NR - MCL not reported.
J - estimated value.
Blanks indicate analyte not reported at method detection limit.
D - analyte was diluted.
JH - estimated high value.
BOLD indicates concentration equals or exceeds CO MCL.

Table 7-2
Summary of Maximum Reported Semivolatile Organic Compound Concentrations
Former Warehouse Area Site Investigation

Compound	Former AF Motor Pool			Former Depot Area			Background		MCL[1]
	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Groundwater (µg/l)	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Groundwater (µg/l)	Surface Soil (µg/kg)	Groundwater (µg/l)	Groundwater (µg/l)
SVOCs									
2-Methylnaphthalene		4100							
Acenaphthene		200 J							
Acenaphthylene				40 J					
Anthracene		380							
Benzo(A)anthracene		830		280 J					
Benzo(A)pyrene		460		270 J					
Benzo(B)fluoranthene		770		510					
Benzo(G,H,I)perylene	59 J	250 J		210 J					
Benzo(K)fluoranthene	45 J	210 J		180 J					
Benzoic Acid							51 J		
Bis(2-Ethylhexyl)phthalate	49 J			92 J		17 B	45 J	1.9 J	NR
Butylbenzylphthalate			1.2 J		40 J	2.3 J		1.7 J	NR
Chrysene	49 J	990		380					NR
Di-N-Butylphthalate	58 J	58 J	1.3 J	59 JB	42 J	1.3 J	72 JB	1.4 J	NR
Dibenz(A,H)anthracene		80 J		48 J					
Dibenzofuran		94 J							
Diethylphthalate	320 J								
Fluoranthene	69 J	2000		530					
Fluorene		170 J							
Indeno(1,2,3-cd)pyrene	46 J	270 J		210 J					
Naphthalene	62 J	2000							
Phenanthrene	230 J	2000		120 J					
Pyrene	64 J	1900		560					

Note: [1] - Maximum Contaminant Level - Colorado Primary Drinking Water Regulations, Code of Colorado Regulations, Title 5, Chapter 1003, September 30, 1994. Updated November 30, 1995 (6 CCR 1007-3, Part 264 Subpart F 264.94).
NR - MCL not reported.
B - analyte was reported in blank sample.
* - laboratory contaminant.
J - estimated value.
Blanks indicate analyte not reported at method detection limit.

Table 7-3
Summary of Maximum Reported Pesticides, Herbicides, PCBs, VPH, EPH, and Percent Moisture
Former Warehouse Area Site Investigation

Compound	Former AF Motor Pool Area			Former Depot Area			Background	
	Surface Soil	Subsurface Soil	Groundwater	Surface Soil	Subsurface Soil	Groundwater	Surface Soil	Groundwater
PESTICIDES/HERBICIDES/PCBs								
Aroclor-1260	ND	ND	ND	59 µg/kg	ND	ND	ND	ND
VPH	170 µg/kg	72000 D JH µg/kg	ND	ND	ND	2100 µg/l	ND	ND
EPH	170 mg/kg	120 mg/kg	ND	130 mg/kg	ND	ND	64 mg/kg	1.9 mg/l
PERCENT MOISTURE	12.8 %	19.8 %	NA	16.2 %	20.8 %	NA	14.2 %	NA

Note: ND - analyte not reported at method detection limit.
NA - not analyzed.
D - analyte was diluted to bring within instrument calibration or to remove matrix interferences.
JH - estimated high value.

Table 7-4
Summary of Maximum Reported Total and Dissolved Metals Concentrations
Former Warehouse Area Site Investigation

Compound	Former AF Motor Pool			Former Depot Area			Background		MCL[1]
	Surface Soil (mg/kg)	Subsurface Soil (mg/kg)	Groundwater	Surface Soil (mg/kg)	Subsurface Soil (mg/kg)	Groundwater	Surface Soil (mg/kg)	Groundwater	Groundwater
Antimony (total)	ND	ND	ND	ND	ND	ND	ND	ND	
Arsenic (total)	5.0 JL	18	ND	4.0 JL	5.4 JL	ND	2.6	2.4 µg/l	50 µg/l
Beryllium (total)	1.0	1.3	ND	1.1	1.6	ND	1.0	ND	
Cadmium (total)	1.1	0.63	ND	3.9	0.90	ND	0.96	ND	
Chromium (total)	17	24	ND	26	33 JH	**0.92 D mg/l**	19 JH	ND	0.05 mg/l
Copper (total)	19	56	0.035 mg/l	24	45	0.016 mg/l	19 JH	0.012 mg/l	1.3 mg/l
Lead (total)	70	19	8.0 µg/l	120	24	1.4 µg/l	64	17 µg/l	50 µg/l
Mercury (total)	0.20	ND	ND	ND	ND	ND	ND	ND	
Nickel (total)	16	18 JL	ND	15 J	170 J	ND	15	ND	
Selenium (total)	ND	0.28 JL	**110 µg/l**	ND	ND	**82 µg/l**	ND	**380 µg/l**	10 µg/l
Silver (total)	0.88	ND	ND	78	2.2	ND	0.69	ND	
Thallium (total)	0.29	0.44	ND	0.32	0.53	ND	0.23	ND	
Zinc (total)	230 JH	99	0.08 mg/l	190	110	0.03 mg/l	70 JH	0.15 D mg/l	NR
Antimony (dissolved)	NA	NA	ND	NA	NA	ND	NA	ND	
Arsenic (dissolved)	NA	NA	ND	NA	NA	ND	NA	ND	
Beryllium (dissolved)	NA	NA	ND	NA	NA	ND	NA	ND	
Cadmium (dissolved)	NA	NA	ND	NA	NA	ND	NA	ND	
Chromium (dissolved)	NA	NA	ND	NA	NA	**0.88 D mg/l**	NA	ND	0.05 mg/l
Copper (dissolved)	NA	NA	ND	NA	NA	ND	NA	ND	
Lead (dissolved)	NA	NA	ND	NA	NA	ND	NA	ND	
Mercury (dissolved)	NA	NA	ND	NA	NA	ND	NA	ND	
Nickel (dissolved)	NA	NA	ND	NA	NA	ND	NA	ND	
Selenium (dissolved)	NA	NA	**110 µg/l**	NA	NA	**80 µg/l**	NA	**400 µg/l**	10 µg/l
Silver (dissolved)	NA	NA	ND	NA	NA	ND	NA	ND	
Thallium (dissolved)	NA	NA	ND	NA	NA	ND	NA	ND	
Zinc (dissolved)	NA	NA	ND	NA	NA	ND	NA	ND	

Note: [1] - Maximum Contaminant Level - Colorado Primary Drinking Water Regulations, Code of Colorado Regulations, Title 5, Chapter 1003, September 30, 1994. Updated November 30, 1995 (6 CCR 1007-3, Part 264 Subpart F 264.94).

NR - MCL not reported.
ND - analyte not reported at method detection limit.
NA - not analyzed.
* - laboratory contaminant.
JH - estimated high value.
JL - estimated low value.
BOLD indicates concentration equals or exceeds CO MCL.

VOCs and SVOCs detected within surface soils of the Former AF Motor Pool area included acetone, xylenes, methylene chloride, toluene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, diethylphthalate, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, VPH, and EPH. Detections of organic COPC were most numerous on the east side of the USTs, northwest of the concrete pad, and in the southwest corner of the Former AF Motor Pool area. The highest reported concentration of VOCs, defined by acetone at a concentration of 7,000 μg/kg, was detected in the central southwest portion of the Former AF Motor Pool area and is not associated with other organic compounds.

Subsurface soil VOCs and SVOCs detected at the Former AF Motor Pool area include acetone, methylene chloride, ethylbenzene, xylenes, 2-butanone, 2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenz(a,h)anthracene, pyrene, chrysene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and di-n-butylphthalate. VPH and acetone occurred in the highest concentrations. The highest concentrations of organic compounds were reported at a depth of 9 to 11 ft bgs on the western side, and from 12 to 14 ft bgs on the northern side of the USTs. Significant concentrations of organics were also reported at 18 to 20 ft bgs at soil boring FWASB04 and from 16 to 18 ft bgs near the center of the Former AF Motor Pool area at soil boring FWASB05. Soil staining and a strong petroleum odor were reported at these sample intervals.

Metals found in surface soils include arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, silver, thallium, and zinc. The maximum concentrations of all detected Former AF Motor Pool surface soil metals were greater than the maximum concentrations of background surface soil metals, but were within the concentration ranges for those metals reported in the western United States.

Subsurface metals detected at the Former AF Motor Pool area included arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, thallium, and zinc. The maximum detected concentrations of arsenic, beryllium, chromium, copper, nickel, selenium, and thallium are greater than the maximum concentrations detected in surface soil metals, but within the concentration ranges for those metals reported in the western United States.

Monitoring wells FWAMW06 and FWAMW07 were positioned downgradient of the Former AF Motor Pool area to determine impact on the groundwater of the surficial aquifer. Low levels of VOCs and SVOCs reported in groundwater samples include 1,1-dichloroethene, 1,2-dichloroethene, carbon tetrachloride, PCE, butylbenzylphthalate, and di-n-butylphthalate. Carbon tetrachloride was detected above CO MCLs. Acetone was not detected in any groundwater sample, although it was commonly reported in significant concentration within soil. The majority of VOCs were detected in groundwater from monitoring well FWAMW06.

Copper, lead, selenium, and zinc were detected in groundwater from the Former AF Motor Pool area. Selenium, the only dissolved metal detected, occurs above the CO MCLs, but its concentration was less than local background groundwater concentrations. Selenium

groundwater concentrations were approximately 10 times greater at monitoring well FWAMW06 than at FWAMW07.

Conclusion:

Two USTs and their associated piping, the foundation of the fuel pump island, and concrete pad are the only visible structures remaining at the Former AF Motor Pool area. Demolition debris and underground utilities are present in the general area. Organic compounds impact surface soils on the east side of the USTs, northwest of the concrete pad, and in the southwest area of the motor pool investigation area. Subsurface soils to a depth of 20 ft bgs on the western and northern sides of the USTs and within the center of the Former AF Motor Pool area are impacted by organic compounds. Reported soil metal concentrations exceed local background surface soil values but do not exceed concentration ranges for metals reported in the western United States.

Depth to groundwater is approximately 20 ft bgs. Groundwater flow of the surficial aquifer in the vicinity of the Former AF Motor Pool area is toward the northwest at an average rate of 2.4 ft/yr. Groundwater immediately downgradient of the area is impacted by several VOCs and SVOCs. Of these compounds, the reported concentration of carbon tetrachloride exceeds the CO MCL for this compound. Reported groundwater concentrations for total and dissolved selenium exceeded CO MCL but were less than local background concentrations.

Suspected source areas within the Former AF Motor Pool area include the two USTs and associated piping and fuel pump island, the west side of the concrete pad, the southwest corner of the investigated area at FWASB07, and an area located in the center of the investigated area in the vicinity of soil boring FWASB05.

7.2.3 Former Depot Area Occurrence and Distribution of COPC

The magnetic and EM geophysical survey of Former Warehouse 505 of the Former AF Motor Pool area indicates the site is magnetically quiet, except for cultural features. Two narrow strips of relatively high conductivity were observed. One is interpreted to relate to the change in soil conditions from a uniformly low conductivity dry road-base material to a fairly conductive moist soil that is present northward beyond the road. The second east-west linear conductivity feature is interpreted as a shallow buried conductive object, possibly an abandoned utility line, that may have been a utility conduit that once served the warehouse.

Organic compounds detected in Former Depot area surface soils included acetone, toluene, PCE, 2-butanone, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, dibenz(a,h)anthracene, di-n-butylphthalate, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, EPH, and the PCB compound aroclor-1260. Most compounds were detected near their respected analytical detection limit. Acetone, PCE, fluoranthene, benzo(b)fluoranthene, chrysene, and pyrene are the most common occurring COPC. The highest concentration of organic compounds in surface soils occurs in soil areas not recently disturbed by demolition activities

located between warehouses 506, 507, 515, and 516, and in the paved area north of former Warehouses 506 and 507.

Subsurface soil organic VOCs and SVOCs detected within the Former Depot area included acetone, methylene chloride, toluene, PCE, 2-butanone, TCE, butylbenzylphthalate, and di-n-butylphthalate. The number and the maximum concentration of subsurface VOCs and SVOCs are less than surface soils; however, the distribution of PCE increased and was detected in the deepest soil sampling interval at six locations.

Pesticides and herbicides were not detected in surface or subsurface soils at the Former Depot area. PCBs were not detected in subsurface soils.

Metals detected in Former Depot area surface soil samples include arsenic, beryllium, cadmium, chromium, copper, lead, nickel, silver, thallium, and zinc. The maximum concentration of all detected Former Depot area surface soil metals was greater or equal to the maximum concentration of local background surface soil metals but within the concentration ranges for those metals reported in the western United States.

Metals reported in subsurface soil samples collected from the Former Depot area include arsenic, beryllium, cadmium, chromium, copper, lead, nickel, silver, thallium, and zinc. Concentrations of arsenic, chromium, copper, nickel, and thallium slightly increased relative to surface soil concentrations but was within the concentration ranges for those metals reported in the western United States.

Three monitoring points (i.e., monitoring wells FWAMW03, FWAMW04, and piezometer FWAPZ5), located downgradient of the Former Depot area, were used to investigate COPC within groundwater of the surficial aquifer. PCE was reported in three and TCE in two of the downgradient monitoring wells above the CO MCL limit of 5 μg/l. Maximum concentrations of PCE and TCE were reported within monitoring well FWAMW03 at 6,400 μg/l and 170 μg/l, respectively. PCE and TCE were also detected in soil from the Former Depot area. VPHs were detected at piezometer FWAPZ05 and monitoring well FWAMW05. Acetone was not detected in any groundwater sample, although it was commonly detected in significant concentration within soil and soil gas samples.

Chromium, copper, lead, selenium, and zinc were detected in Former Depot area groundwater. Both total and dissolved chromium and selenium groundwater metal concentrations exceed CO MCL of 0.05 mg/l and 10 μg/l, respectively.

Conclusion

Warehouses 515 and 516 are the only structures remaining within the area of investigation of the Former Depot. Warehouses 505, 506, and 507/OMS 9 have been demolished. The geophysical survey identified an abandoned underground utility line along the north and west side of Warehouse 505; however, a UST, dry well, or similar structure was not identified.

Acetone, PCE, fluoranthene, benzo(b)fluoranthene, chrysene, and pyrene are the most common occurring VOCs and SVOC in surface soils and occur in recently undisturbed soils located between former Warehouses 506, 507, 515, and 516, and in the paved area north of former Warehouse 506 and 507. VOCs and SVOCs detected in subsurface soils included acetone, methylene chloride, toluene, PCE, 2-butanone, TCE, butylbenzylphthalate,and di-n-butylphthalate. The distribution of PCE within subsurface soil is greater than surface soils and is reported in the deepest soil sampling locations around Warehouse 505 and on the north side of Warehouse 516. Surface soil metal concentrations are greater or equal to the maximum concentration of local background surface soil metals. Both surface and subsurface soils metal concentrations are within the concentration ranges for those metals reported in the western United States.

Depth to groundwater is approximately 18 ft bgs. Groundwater flow within the surficial aquifer is northward toward the USCWTP at an average rate of approximately 2.4 ft/yr. PCE was reported in three and TCE in two of the downgradient monitoring wells above the CO MCL limit of 5 µg/l. Both total and dissolved chromium and selenium groundwater metal concentrations exceed CO MCL.

Suspected contaminant source areas within the Former Depot area include the area directly adjacent to the west, south, and east of Former Warehouse 505; the area between Former Warehouse 507/OMS 9 and Warehouse 516; and the area north of Former Warehouse 505 in the vicinity of soil boring FWASB14.

8.0 RECOMMENDATIONS

The FWA SI has determined groundwater contaminants discovered at the USCWTP are also present at the FWA. This was concluded by conducting an environmental field investigation involving a geophysical survey, followed by the collection and analysis of soil gas, soil, and groundwater samples within the FWA. Results of the FWA SI confirmed the presence of VOCs, SVOCs, and metals in soils and groundwater. Groundwater contained carbon tetrachloride, chloroform, PCE, TCE, chromium and selenium at concentrations equal to or greater than CO MCLs. However, the source area(s) and movement within groundwater of these organic compounds and metals have not be determined. Therefore, it is recommended that a RI be conducted to define the nature and extent of soil and groundwater contaminants at the FWA.

The following list provides recommendations of field investigation activities to be included as part of the RI for the FWA. These recommendations are based on the need to further define the nature and extent of VOCs, SVOCs, and metals within soil source areas and in groundwater.

1. Locate additional background sampling location(s) for the FWA. Background locations should be positioned away from potential contaminant sources. Sample and analyze soil and groundwater for VOCs, SVOCs, and PP metals.
2. Conduct additional surface soil sampling in the vicinity of the Former AF Motor Pool area. Samples should be collected along the western and southeastern portion of the area and analyzed for VOCs and SVOCs. Because most soil within the area has been disturbed, two sets of surface soils should be considered. One set of surface soil samples should be collected from the disturbed soil and the other set from the undisturbed soil directly underlying the disturbed soil.
3. Conduct additional subsurface soil sampling in the vicinity of the Former AF Motor Pool area to determine the extent of VOCs and SVOCs identified by the FWA SI. Additional soil borings should be located in the vicinity of soil boring locations FWASB05 and FWASBN07 to determine the depth of VOCs and SVOCs within soils. Soil samples, collected from the land surface to the water table, should be analyzed for VOCs and SVOCs. If significant concentrations of organics are found in surface soils, then subsurface soil samples should be collected and analyzed at those locations.
4. Conduct additional surface soil sampling at the Former Depot area. Surface soil samples should be collected and analyzed from along the entire length of former railroad tracks and warehouses extending from Warehouses 501/509 to 504/513. Soil samples should also be collected and analyzed from the south side of Warehouses 515 and 516. Soil samples should be analyzed for VOCs, SVOCs, and PP metals. Because most soil within the area has been disturbed, two sets of surface soils should be considered. One set of surface soil samples should be collected from the disturbed soil and the other set from the undisturbed soil directly underlying the disturbed soil.

5. Additional subsurface soil samples should be obtained from the Former Depot area to determine the vertical extent of COPC identified by the FWA SI. Borings completed to the water table should be located in the vicinity of FWA SI soil borings FWASB10, FWASB12, FWASB13, FWASB14, FWASB15, and FWASB20. Subsurface soil samples should also be collected at additional surface soil sampling locations where significant concentrations of organic COPC are detected. Subsurface soil samples should be analyzed for VOCs.

6. COPC were detected in the surficial aquifer at or above the CO MCLs at both FWA SI study areas. Groundwater monitoring of the surficial aquifer should be conducted downgradient of the Former AF Motor Pool and Former Depot areas.

7. Long-term monitoring of groundwater levels should be conducted to investigate the seasonal changes and the effects of precipitation/infiltration and evapotranspiration on groundwater levels of the surficial aquifer.

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